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DAIRY SCIENCE

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CONTENTS

People and Events 3

Dairy Technology Society News 17

Notes from the Secretary's Desk 18

Student Chapter News 23

Research Papers:

Significance of Strontium[90] in Milk. II. A Review of Recent Data and Analysis of Areas Needing More Elaboration to Define the Role of Milk in the Diet. B. L. Larson 1

The Rapid Determination of Minerals and Ions in Milk. II. Determination of Chloride. V. R. Wenner 22

Relative Cleanability of Various Stainless Steel Finishes After Soiling with Inoculated Milk Solids. O. W. Kaufmann, T. I. Hedrick, I. J. Pflug, C. G. Pheil, and R. A. Keppeler 28

Influence of Vacuum Pasteurization upon the Freezing Point Value, Total Solids, and Concentration of Fluid Milk. J. T. Lazar, Jr. and R. W. Henningson 42

Determination of Curd Making Quality of Nonfat Dry Milk. W. K. Stone, P. M. Large, and G. C. Graf 48

Genetic and Phenotypic Relationships Between Clinical Mastitis, Laboratory Criteria, and Udder Height. C. W. Young, J. E. Legates, and J. G. Lecce 54

Rates of Improvement by Progeny Testing in Dairy Herds of Various Sizes. L. W. Specht and L. D. McGilliard 63

Physical and Chemical Changes in Bovine Saliva and Rumen Liquid with Different Hay-Grain Rations. R. S. Emery, C. K. Smith, R. M. Grimes, C. F. Huffman, and C. W. Duncan 76

Effect of Several Variables on in Vitro Rumen Fermentation. D. C. Church and R. G. Petersen 81

Technical Notes:

Inhibition of Oxidized Flavor in Homogenized Milk as Related to the Concentration of Copper and Phospholipids per Unit of Fat Globule Surface. N. P. Tarassuk and J. Koops 93

The Action of Pancreatic Lipase on Milk Fat. Stuart Patton, Laura Evans, and R. D. McCarthy 95

Some Evidence Supporting the Specificity of Milk Lipases for the Primary Hydroxyl Positions of Milk Glycerides. R. G. Jensen, A. H. Duthie, G. W. Gander, and M. E. Morgan 96

Comparative Serum Constituents in Brahman and Angus Cows. E. S. Erwin 98

Effect of Solar Radiation on Variations of Blood Constituents in Cattle. H. M. Page, E. S. Erwin, and G. E. Nelms 99

Interpretive Summaries of Papers 101

(Continued on inside front cover)

CONTENTS

(Continued from front cover)

Symposium: Student Enrollment Trends in Agricultural Colleges

Introduction. **J. T. Lazar** 110

The Status of Dairy Manufacturing Majors in the Land Grant Colleges of the United States and Canada. **P. H. Tracy** 110

Enrollment Trends in Dairy Production. **N. P. Ralston** 111

Enrollment Trends in Agricultural Colleges. **J. W. Jones** 113

Our Industry Today:

Reappraisal of the Quality Control of Milk Supplies from Farm Bulk Tanks. **A. C. Fay** 116

Strontium^{90} and Milk. Considerations on Sr^{90} and the Role of Milk in Our Diet. **B. L. Larson and K. E. Ebner** 119

Our Association:

Officers, Committees, and Representatives of the American Dairy Science Association 125

Announcement of the Graduate Student Award Programs 132

Daryl Chase's Welcome to Members of the American Dairy Science Association 132

Program Annual Meeting of Southern Division 133

CALL FOR PAPERS FOR THE 1960 ANNUAL MEETING
of the
American Dairy Science Association
See October Journal, page 1734

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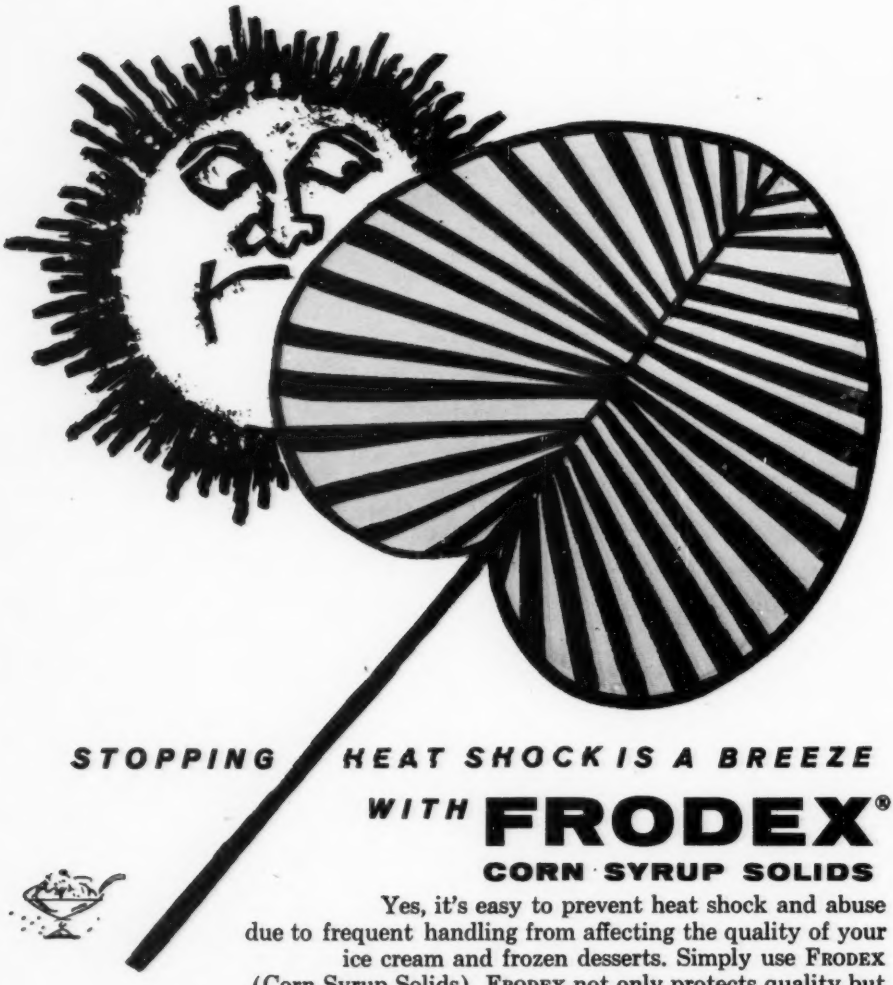

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PEOPLE AND EVENTS

The Borden Award of $1,000 and Gold Medal in Dairy Chemistry to Dr. E. L. Jack

DR. E. L. JACK, of the Department of Food Science and Technology at the University of California, was the recipient of the American Chemical Society prize in chemistry, sponsored by the Borden Foundation.

Dr. Jack's career has taken him from a practical farmer to the highest achievements in Dairy Science. Following his service in World War I he was, for seven years, a dairy farmer specializing in Holstein-Friesian cattle. He was herdsman for the Pennsylvania Department of Welfare for three years. Then, at an age when most young men have already been established in their professional careers, he earned the B.S. degree in 1933, the M.S. degree in 1934, and the Ph.D. degree in 1936, all from Pennsylvania State University. The following year he served as a research chemist for the Borden Company. In 1937, Dr. Jack accepted a position as Assistant Professor of Dairy Industry at the University of California, becoming Associate Professor in 1944, and was promoted to Professor and Chairman of the Department in 1947.

E. L. Jack

In Dr. Jack's relatively short academic career, he has been the author and coauthor of 75 technical and scientific papers on the chemical and nutritional value of milk fat and on the properties and uses of dry milk. During his chairmanship of the Department of Dairy Industry, he assembled a staff of chemists, bacteriologists, and technologists whose contributions have been outstanding.

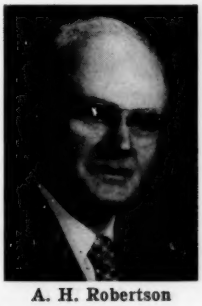
Dr. Jack has been active in the American Dairy Science Association, having served as secretary of the manufacturing section in 1950; chairman in 1952; director from 1958–60; and chairman of the Education Committee from 1956–57. He was President of the Western Division in 1949–50. In 1953 he was official delegate to the 13th International Dairy Congress at The Hague. Dr. Jack is a member of the following organizations: Alpha Zeta, Sigma Xi, Phi Kappa Phi, Gamma Sigma Delta, American Dairy Science Association, American Chemical Society, Institute of Food Technologists, American Oil Chemists Society, Commonwealth Club of California, California Dairy Industries Association, California Dairy Council—Director, and Associates—Food and Container Institute.

Dr. Jack resigned from the chairmanship of the Department of Dairy Industry [J. Dairy Sci., 42: (6) 3. 1959, People and Events] and has returned to teaching and research in the newly created Department of Food Science and Technology at the University of California.

A. H. Robertson Retires

A. H. ROBERTSON retired November 18 after nearly 30 yr. as Director of the State Food Laboratory in the New York State Department of Agriculture and Markets.

The Food Laboratory analyzes and tests foods to determine whether they conform to recognized standards of composition and identity and whether they are safe for table use. Chemical tests are often supplemented by taste tests to determine the fitness of food.



A. H. Robertson

Dr. Robertson has gained world-wide recognition for his achievements as an agricultural chemist. He has just completed a term as president of the nation-wide Association of Official Agricultural Chemists. Before assuming the presidency, he served as committee chairman on methods and on the editorial board for some of the organization's most important publications. The Food Laboratory chief edited the ninth and tenth editions of *Standard Methods for the Examination of Dairy Products* for the American Public Health Association.

Commissioners and directors of the Department of Agriculture and Markets and other employees of that agency of the State honored Dr. and Mrs. Robertson at a testimonial dinner at the Aurania Club in Albany on October 26.

Dr. Robertson is known as one of the leading dairy bacteriologists of the United States and is especially interested in the problems confronting him and his fellow chemists with frozen foods. Historical development of frozen foods, their commercial expansion, and their future, and the problems of sanitation, have especially engaged Dr. Robertson's attention.

Dr. Robertson was born at Lounsberry, Tioga County. He attended the Owego Free Academy. All of his undergraduate and graduate work was taken at Cornell University. He was graduated in 1920 after a delay caused by his military service in World War

I, receiving his master's degree in 1924, and his doctor's degree in 1927.

One year as city bacteriologist at Geneva, 5 yr. as assistant bacteriologist at the State Agricultural Experiment Station at Geneva, New York, and nearly 3 yr. as bacteriologist at the State Agricultural Experiment Station at Burlington, Vermont, preceded his appointment October 1, 1928, as bacteriologist in the State Department of Agriculture and Markets at Albany, New York. He was appointed Director of the State Food Laboratory on June 1, 1930. The laboratory occupies an entire wing of the 21st floor of the State Office Building. Seven chemists and a bacteriologist are employed there.

In addition to his early work at Albany on licensing individuals to make bacterial counts, and the inspection of laboratories in which those operations took place, Dr. Robertson has devoted his years of public service to directing the chemical tests for determining adulteration or misbranding of food. The Department is charged by law with the promotion of agriculture and the prevention of fraud and misrepresentation when food is marketed.

COLLEGE AND UNIVERSITY NEWS

Utah State Plans for Annual Meeting of A.D.S.A.

Major committee assignments have been made, and preliminary plans for the 1960 meeting of the American Dairy Science Association have been completed, at Utah State University. A. J. Morris, dairy science department head at USU and chairman of local arrangements, told members of the A.D.S.A. executive committee in Chicago on November 29 that Utah State is making elaborate plans to entertain the dairy scientists.

Dr. Daryl Chase, USU president, has pledged full use of facilities at Utah's Land Grant University and has offered the services of the staff to assure success of the A.D.S.A.'s 55th annual conference, Professor Morris told A. C. Fay, president of A.D.S.A., and other members of the Association's executive committee.

Dates for the 1960 meetings are June 19–22 and plans are being forged to accommodate as many of the 2,600 members in A.D.S.A. as can possibly attend.

Utah State University's campus is situated on a delta of ancient Lake Bonneville, overlooking Cache Valley, one of Utah's most productive and picturesque mountain valleys. Nearby recreational areas include Grand Teton and Yellowstone National Parks, Jackson Lake, Bear Lake, and many mountain retreats. A number of Midwest dairy scientists have indicated they intend to make the Utah conference the occasion for a family vacation. Utah Agricultural Experiment Station's dairy research farm and other research facilities will be among items of special interest to visitors.

Death of National DHIA Leader at California

E. G. Gordon, 67, pioneer in DHIA work in California, died May 29, 1959, at his home in Berkeley, California.

Mr. Gordon received his B.S. Degree from the University of California in 1917. During the succeeding years he served in the various capacities of herdsman, dairyman, dairy farm advisor, and from 1924 until his death was extension dairyman at the University of California Agricultural Extension Service.

His campaign on DHIA, dairy breeding, and nutrition, and the training and assistance he provided county agents, were instrumental in elevating the production of California dairy cows to the highest level in the nation. He was a dairy judge of international prominence. The major shows he judged included the National Dairy Congress, the International Exposition, the Pacific International, the Grand National, the Pacific National Exposition of Canada, and the National Holstein and Brown Swiss shows in Bogota, Colombia.

In recognition of these many achievements, the DeLaval Award was bestowed upon Mr. Gordon in 1953, and on June 9, 1959, California, by resolution of its Senate, acknowledged posthumously his contributions to the State.

Mr. Gordon was survived by two sons, Gillette Eddy Gordon, III, of Baltimore, Maryland, and Douglas H., of Berkeley, California; a sister and two brothers.

Report on Symposium on Foods: Enzymes Held at Oregon State College

A Symposium on Foods: Enzymes, sponsored by the Department of Food and Dairy Technology of Oregon State College and the National Institute of Health, was hold at Corvallis, Oregon, September 9–10. Some 200 scientists from throughout the West attended and heard discussions on past accomplishments, the present status, and future research problems related to enzymes and their role in foods.

The enzyme symposium was one of the several symposia held on the Oregon State College campus in conjunction with the celebration of the Oregon Centennial. It was also held to honor Professor Ernest H. Weigand, retired head of the Oregon State College Food Technology Department, for his 40 years of service to the Oregon Food Industry.

H. W. Schultz, Head of the Food and Dairy Technology Department, said that this symposium was a beginning of symposia in food science to be held at Oregon State College. He also announced that papers presented at the symposium will be published in book form by the Avi Publishing Company.

Dr. E. M. Mrak, Chancellor and Professor of Food Technology, University of California, Davis, emphasized the importance of enzymes

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in the field of food science. Today enzymes are finding their proper place of importance in food research and it is recognized that while some may create undesirable effects in foods, others may be used to a great advantage, he said.

Dr. David E. Green, Co-director, Institute for Enzyme Research, University of Wisconsin, discussed the future of enzymology. He pointed out that a foundation of the subject of enzymology was laid in the period prior to 1940 in Europe, but it was in this country during the '40's and '50's that enzymology skyrocketed from a pigmy to a giant, dominating the field of biochemistry. The classical problems have been pared to the bone and many of the once-flourishing frontier areas have become quiescent. The less spectacular but more difficult problems remain to be solved. Important unsolved problems for the enzymologist include the mechanisms of hormone action, oxidative phosphorylation, gene action, muscular contraction, protein synthesis, and the entire problem of biological organization.

Dr. Paul K. Stumph, Professor of Plant Biochemistry, Department of Biochemistry, University of California, discussed the enzymes affecting food lipids. The importance of lipids as a food and as a means of storing energy, and the known mechanisms for their degradation and synthesis, were reviewed. The role of lipogenin as a new and important regulator in lipogenesis and the function of vitamins in lipid utilization by humans were stressed. Dr. Ralph T. Holman, Professor of Physiological Chemistry, University of Minnesota, reviewed the mechanism of lipoxidase action on polyunsaturated fatty acids and the implications of such phenomena to the nutritive value and acceptability of foods. In no case has lipoxidase been demonstrated in animal tissue; rather, it is the catalytic activity of heme compounds present that is responsible for lipid oxidation in animal tissue in many instances. Mention was also made of recent findings in which the polyunsaturated fatty acids have been found to constitute a high percentage of the fatty acids in mitochondria and it was suggested that they may function as prosthetic groups of enzymes.

Dr. David R. Goddard, Director of the Division of Biology, University of Pennsylvania, emphasized the need for research on biological organization in his discussion of enzymes effecting oxidative browning. An example of this problem is the presence of large quantities of oxygen in plant tissue and it is not until some damage has resulted in the tissue that polyphenoloxidase catalyzes the formation of brown pigments.

Dr. James D. Ponting, Western Regional Research Laboratory, USDA, pointed out that the mechanism of polyphenoloxidase inactivation by sulfur dioxide has never been unraveled and that it is essential to know the oxygen content of fruit and vegetable tissue mentioned by Dr. Goddard in order to know the type of treatment necessary for preservation of the food. Other than sulfur dioxide, new methods involving heat inactivation appear promising for prevention of enzymatic browning, as do methods of controlling pH in the system. It was interesting to note that malic acid is more effective than citric acid in inhibiting the browning of apple juice. This was not attributed to a change in pH alone.

Dr. Vernon H. Cheldelin, Director, Science Research Institute, Oregon State College, described the pathways of carbohydrate degradation and synthesis, including the most recent information on the Pentose Cycle. Dr. Z. I. Kertesz, Professor of Chemistry, Cornell University, pointed out that similar progress has not been made in describing the enzymes involved in the syntheses pathways for the formation of cellulose and pectins. Incorporation of simple glucose and galactose into the cellulose molecule is well recognized, but the steps involved are not known. Methyl donors contribute methyl groups but, again, mechanisms for this reaction as well as polymerization steps are still to be determined. The danger of using substrates other than the native system for a particular cellulase test was pointed out. For example, the use of carboxymethylcellulose as a common substrate for a cellulase test may give dubious results.

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Dr. A. J. Balls, Professor of Enzyme Chemistry, Purdue University, dealt with enzymes affecting proteins and the phenomenon of enzyme regeneration. In the process of heat denaturation, the denatured proteins are more susceptible to proteolysis. The enzymes also are denatured but not necessarily at the same rate. The total effect, therefore, on a food system is a matter of timing. The enzymes that stay undenatured longest can digest the less heat-resistant proteins and in the regeneration process the enzymes that revert most rapidly can hydrolyze the slower-reverting food proteins. Caution should be taken in the development of high-temperature, short-time equipment for food processing, since foods treated in this manner may be more susceptible to enzyme regeneration, he said.

Dr. B. S. Schweigert, Director of Research and Education, American Meat Institute Foundation, discussed the importance of catheptic enzymes in aging and tenderization of meat. He also pointed out the value of using other proteolytic enzymes for the tenderization process. Aside from the problem of selecting the proper enzyme preparation, penetration and distribution of enzymes throughout the tissue is a critical factor in obtaining satisfactory results.

In summarizing the symposium, Dr. Mrak emphasized the need for greater cooperation between the different areas of scientific discipline. Greater exchange of ideas and knowledge, and the utilization of team effort, will result in more rapid progress in the area of food science and technology.

The symposium was concluded by a look at the perspectives in food research by the late Dr. B. E. Proctor, Head (before his death on October 24, 1959), Department of Food Technology, Massachusetts Institute of Technology. Food research is now recognized as a factor of primary importance to all nations large and small, because of the population increases which are taking place all over the world. These population gains make food a factor of existence in some areas, while in others it may be intimately connected with dreams of domination. Consequently, the importance of producing both quantity and quality of foods, as well as assuring its delivery to the consumer in the most acceptable form, are problems of immediate and continuing consideration to the food industry. A food researcher must not only stay abreast of the basic problems but he must also be constantly cognizant of the changing attitudes, health, and well-being of the consumer. This may be summed up by saying that the consumer wants quality and convenience at a reasonable price. Enzymology undoubtedly will play an important role in providing the consumer with these requirements, he said.

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Georgia

The second Better Foods for Better Nutrition Conference, a conference jointly sponsored by the Divisions of Foods and Nutrition and Food Processing of the University of Georgia, will be held March 3–4, 1960, at the Center for Continuing Education, University of Georgia, Athens.

This conference is planned for persons engaged in research, extension, and teaching of foods and nutrition or food technology, as well as for home economists in business, for lunchroom supervisors, hospital dietitians, public health nutritionists, and handlers and processors of foods. Special attention will be given to industrial and institutional problems in processing, handling, and serving foods. Nationally recognized authorities will appear on this program to present the latest information.

Anyone desiring further information, may write DR. J. J. POWERS or the Center for Continuing Education.

On September 22 students in the Dairy Department at the University of Georgia started the fall quarter off with a bang—a Chicken Bar-B-Que cooked under the supervision of the chief himself—Professor H. B. HENDERSON, Head of the Dairy Department. About 125 students and their guests enjoyed the delicacy sponsored by one of the local dairies. It was a success.

Twenty-seven majors in the department, which included all junior and seniors, joined the American Dairy Science Association as affiliate members. With this large increase in membership, the University of Georgia Chapter expects to take all honors in the student competition in the A.D.S.A. An attempt is being made to have 100% of the students in the Dairy Department enroll as active members of the Dairy Science Club.

The University of Georgia was host to the Southern Dairy Products Judging Contest, October 2, at which three members of the Georgia Dairy Science Club brought honor to their institution by winning the all-products cup in the contest. DAN BARRETT, a member of the Georgia team, was top individual in the contest, followed by JOE PAYNE, who placed second in the contest. PAUL HOWSE, the third member of the Georgia team, placed first in butter. Following the contest, the team went to the International Dairy Products Judging Contest in Miami where they placed tenth in judging all products.

The Dairy Department at the University of Georgia has been noted for its outstanding scholarship program. This year was no exception. Sixteen scholarships were awarded, totalling $3,300. These scholarships, with the exception of one, are for $200 each and are awarded by dairy plants and organizations in Georgia. One award of $300 was presented by the Borden Foundation of New York to the outstanding senior, DENNIS DIXON. All of the dairy scholarships are reserved for students beyond the freshman year, since many other scholarships are available for entering freshmen. The Dairy Science Club Banquet, previously held during the fall quarter, will be held this year on January 29. At this time the donors of scholarships will be especially honored and presented a certificate of appreciation for their interest in the dairy students.

Scholarships totaling $3,300 were awarded students in dairying at the University of Georgia at a recent meeting of the Dairy Science Club. The scholarships were made available by dairy firms and organizations in Georgia interested in the student program. Shown above are the students receiving scholarships.

Front row: (Left to right) Frank Servididio, Granite Springs, N.Y.; Robert Seely, Hollis, N.Y.; Sang Ik Chang, Korea; Ernest Pinckney, Mahopac, N. Y.; James B. Carlton, Canon, Ga.

Second row: Dan Barrett, Calhoun, Ga.; George Fincher, Arlington, Ga.; George Norman, Washington, Ga.; Johnny Stone, Hogansville, Ga.; Melvin Durham, Greensboro, Ga.

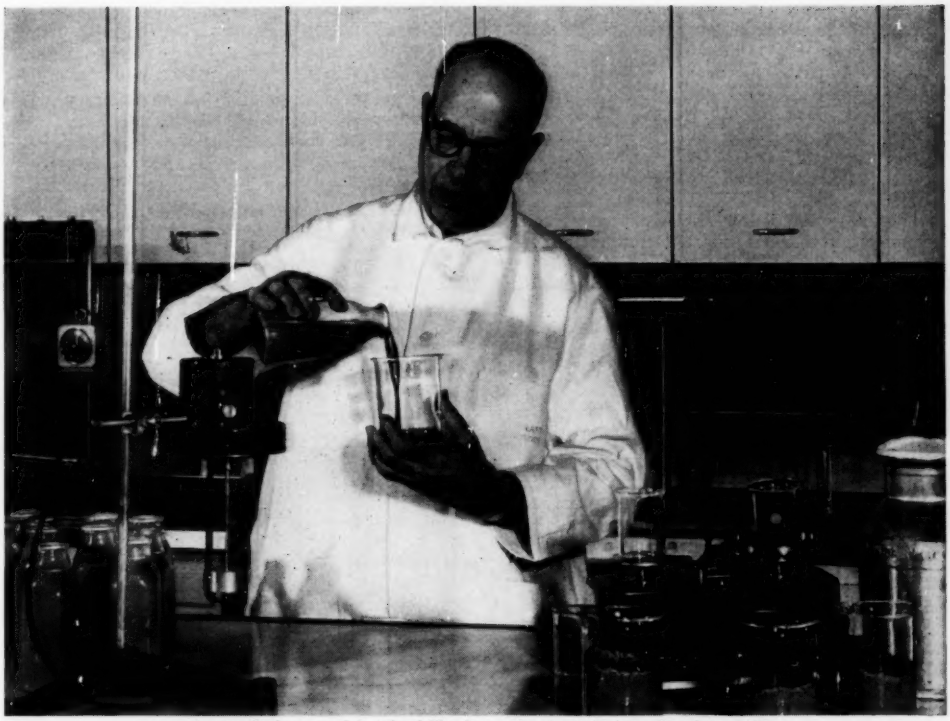
Third row: Paul Howse, Naples, N. Y.; Bobby Walker, Madison, Ga.; Wesley Blair, Boston, Ga.; Donald Eipp, LaFayete, N. Y.; Ralph Adamson, Morrow, Ga., and Dennis Dixon, Starrsville, Ga., winner of the Borden Foundation Agricultural award of $300 as the outstanding senior in the College of Agriculture with two or more courses in dairying.

The final activity of the quarter was our very successful 37th Little International, sponsored jointly with the Saddle and Sirloin Club. Many fine animals were shown in strict competition. Top Jersey showman of the event was JOHN SHAW, with the prize dairy animal being a Holstein, shown by C. R. HAMPTON.

University of Connecticut Holds Career Day

A highly successful Dairy Manufacturing Career Day was held at the University of Connecticut, October 31. Dairy industry personnel in the state recruited and transported the 75 people who attended from schools throughout the state.

Prospective positions and the need for college trained personnel in the dairy industry were discussed by dairy industry speakers.



A sample from each batch of Kraft powder is made into chocolate milk and performance-tested before any of the batch is shipped to dairies.

This is how we make Kraft Chocolate Flavored Powder so uniformly good!

1. We start with top-grade ingredients. Kraft buys only the finest grade cocoa and quality sucrose. Because these ingredients must meet our rigid specifications, you can count on uniformity of color and flavor in the finished product.

2. We make our own stabilizer. Kraft extracts the stabilizer we use from Irish Moss which we harvest ourselves. Our special process assures thorough suspension with the viscosity you desire. You order the formula designed for your system and its high safety range allows adjustments in sweetness and strength without upsetting balance.

3. We manufacture in small batches. Unlike other manufacturers, Kraft makes chocolate powder only in small batches. This permits more exact control over quality. A sample from each batch of Kraft's powder is made into chocolate milk and its performance tested before any of the batch is shipped to dairies.

Samples for classroom work made available to accredited dairy colleges. Just write your nearest Kraft division office.

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Division Offices: New York—Garland, Texas—Chicago—San Francisco

Industry representatives appearing on the program included: H. M. EWELL, Sales Representative of the Pennsylvania Salt Manufacturing Company, Arlington, Mass.; G. E. SARTAIN, Director Field Services, Sealtest Foods, Hartford; DR. R. M. PARRY, Chief of the Dairy Division, State Department of Agriculture, Hartford; and DR. E. A. PERREGAUX, Director of Connecticut Milk for Health, Hartford.

The day included a luncheon handled by the Connecticut Association of Dairy and Food Sanitarians and the Connecticut Milk Dealers' Association, a tour of the dairy manufacturing facilities, and attendance at the Connecticut-New Hampshire football game.

Florida News

FRANCISCO OSEQUEDA has been selected as the recipient of the Borden Award for 1959 at the University of Florida. This award consists of a certificate of achievement and a $300 cash award. It is presented annually to the senior student in the College of Agriculture who has made the highest grade-point average in all work prior to the senior year. He must have taken at least two dairy courses.

Mr. Osequeda was born in San Salvador, El Salvador. He transferred to the University of Florida from Escuela Agricula Pan America and will graduate from the University of Florida in June, 1960.

Mr. Osequeda's present home address is Ambajada de El Salvador, Tegucigalpa, Honduras, Central America. His father is ambassador from El Salvador to Honduras.

He plans after graduation to work for the government of his country for some time, after which he will manage his father's farm.

T. G. Lee Named Outstanding Dairyman In Florida for 1959

T. G. LEE, owner of the T. G. Lee Dairy of Orlando, was named the outstanding Florida dairyman for the year 1959 by the University of Florida Dairy Science Club. The award was presented to Mr. Lee by JACK GAY, president of the Club, at the annual Dairy Field Day Banquet held on Thursday, October 15, at Gainesville.

Jack Gay, right, presenting First Annual Dairy Science Club Award to T. G. Lee.

Mr. Lee was cited for his achievements in the dairy industry and for his contribution to the welfare and progress of the industry. Mr. Lee, who started in the dairy business in 1925, heads one of the largest independent dairies in the state of Florida. In addition to his processing plant, Mr. Lee has two dairy farms with over 1,100 cows. Both his plant and dairies are considered to be among the most modern in the state.

Even though Mr. Lee has been in the dairy business for over 34 years, he still considers himself a student of dairying. He was instrumental in establishing a scholarship for students interested in dairying. He helped to organize the Artificial Breeders Association in Orange County (Orlando).

Outside of the industry also, Mr. Lee is a leader. He is Past Commander of the Orlando

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- Dri-Vac Cultures — Available in Specific Strains
- Culture Flasks
- Culture Cabinets
- All "Hansen's" Dairy Preparations are strictly Kosher

Write for Literature

CHR. HANSEN'S LABORATORY, INC.
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American Legion Post, an elder in the Presbyterian Church, an active member of Kiwanis, and a Shriner.

New York State

A very successful bulk milk handling meeting was held at the Farm and Home Center Building in Middletown, New York, at 4 P.M., October 14, with about 50 people attending. The meeting was high-lighted by a flavor and odor panel. All those attending had been asked to bring samples of milk for judging and a large, representative number of samples were present. The panel was a marked success. PROFESSORS J. C. WHITE and R. P. MARCH from the Department of Dairy Industry, Cornell University, participated on the judging panel.

A two-day conference on Instrumentation in the Food Industries will be held at Cornell University on February 2 and 3, 1960. On the first day of this meeting a program will be presented on fundamental principles involved in instrumentation. The second day there will be presented papers by recognized authorities on specific instruments, such as measuring and recording devices, radiation as a tool, and instrumentation for automatic devices.

Anyone interested is cordially invited to attend.

The dates for the Annual Cornell Farm and Home Week have been set for March 22, 23, and 24, 1960. The theme of this year's program is The Challenge of the Future. On March 23 there will be a program of special interest to dairymen—Dairying in the 1970's.

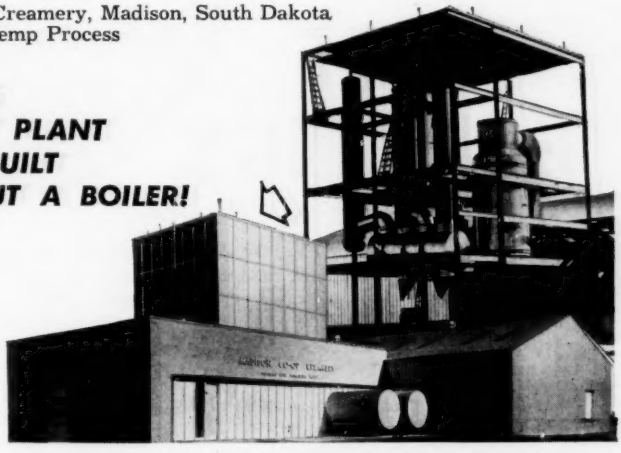
DR. W. K. JORDAN attended the Eastern Regional Annual Research Meeting in Philadelphio, October 27–29, 1959, and spoke on Maple in Milk Products.

The Dairy Industry Department is very proud to announce that a professor of Food Science, DR. PAUL A. BUCK, has newly come to us from Wisconsin. Professor Buck will teach the courses in Food Science and conduct research in the food field. He is interested in all professional societies which have an interest in food or dairy processing. Professor Buck was associated with Heinz Company, doing quality control work, prior to his professorship at Wisconsin. His undergraduate work was done at the University of British Columbia and he earned his graduate degrees at the University of California.

When Farmer's Cooperative Creamery, Madison, South Dakota installed the Mojonnier Lo-Temp Process in its entirely new plant, it became the

WORLD'S FIRST DAIRY PLANT TO BE BUILT WITHOUT A BOILER!

No boiler — no steam — no water — no water disposal problem is the modern day achievement of the Mojonnier Lo-Temp Evaporator--Spray Dryer System. Using the heat pump principle, the system produces 825 pounds of premium grade nonfat dry milk per hour at Farmer's Cooperative on a continuous production basis. Features include in-place cleaning, retention of maximum Whey Protein Nitrogen values, pushbutton operation, and lowest production cost per pound of dried product. Milk is evaporated at temperatures below the cow's body temperature.



Above: A primary feature is that the steel framework which supports the Lo-Temp Evaporator and Spray Dryer equipment also supports the low cost outer sheathing. Arrow points to completed structure.

Full details are in Bulletin 372-18. Write for it today
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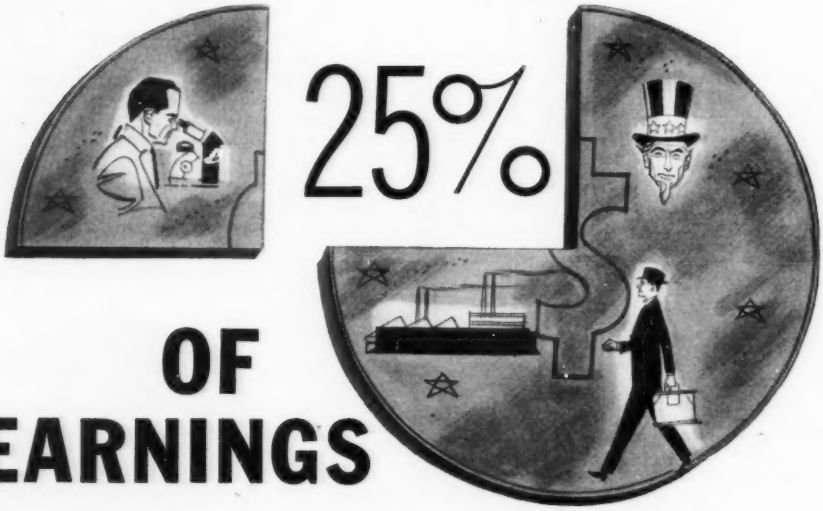
DIVERSEY INVESTS 25% OF EARNINGS



Research—the yardstick by which we prepare for the future—is of first importance at Diversey. Last year our expenditures for Research and Product Development amounted to about 25c of every dollar of pre-tax earnings.

Much of this effort is aimed at applying electronics and atomic physics to Dairy Sanitation. Advanced research like this has led to improved techniques for evaluating results of C-I-P cleaning, for instance.

In new-product development, an example of Diversey's many contributions is a new non-foaming conveyor chain lubricant—DICOLUBE SL. This lubricant provides cleaner, more smoothly operating chains and eliminates the problem of slippery, hazardous floors along conveyor lines.

By constantly searching for better products and methods—solving the small problems as well as the large ones—Diversey advances the science of dairy sanitation . . . helping to insure quality milk and improve dairy efficiency. Perhaps our experience can help you. The Diversey Corporation, 1820 Roscoe Street, Chicago 13, Illinois.

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DR. J. C. WHITE gave three talks at the combined meetings of the Minnesota plant operators, fieldmen, and technical societies in September and was present at the Dairy Industry and Plant Operators Conference in Vermont on October 7 and 8, where he talked on recent developments in pipeline milkers.

Ohio State

Plans are moving forward for the 27th Annual Dairy Technology Conference, to be held February 9–11 at Ohio State University. The areas of discussion will include: (a) field problems, (b) quality control and cultured products, (c) engineering and processing, (d) ice cream, and (e) management. Emphasis will be placed in all areas on the newest developments, their implication and application to the Dairy Industry.

University representatives who will appear on the program include: T. HEDRICK, Michigan State University; J. JEZESKI, Minnesota University; J. C. WHITE, Cornell University; and V. H. NIELSEN, Iowa State University.

GLEN MASSMAN of Glen Massman and Associates, Dayton, will be the featured speaker at the Conference Banquet, February 10.

Wisconsin News

Program

Annual Wisconsin Dairy Manufacturers' Conference

January 27–28, 1960

Department of Dairy and Food Industries,
University of Wisconsin
Madison

WEDNESDAY, JANUARY 27

1:30–4:30

Room 205, Babock Hall

INTEGRATION—ITS PRINCIPLES, PROBLEMS, AND METHODS

Chairman, Professor Marvin Schaars,
University of Wisconsin

Problems and Opportunities of Consolidating Dairy Plant Facilities and Services

W. F. Mueller, University of Wisconsin

2807(1922)—832(1959)—? (1970)

George F. Mooney, Executive Secretary, Wisconsin Cheese Makers' Association, Plymouth

Welcome—Dean R. K. Froker

Combinations of Plants

A. L. McWilliams, Pure Milk Association, Chicago, Ill.

Improving Efficiency in Milk Procurement and Movement

Dave Nusbaum, L. D. Schreiber and Company, Green Bay

Legal Angles to Consider

Douglas Milsap, Legal Section, Wisconsin State Department of Agriculture, Madison

Market Milk Conference

THURSDAY, JANUARY 28

8:45–11:30

Room 205, Babcock Hall

SOLIDS-NOT-FAT, THE NEW PARTNER IN THE MARKET MILK INDUSTRY

Chairman, Professor H. E. Calbert
University of Wisconsin

What Does the Use of Solids-not-fat Mean to Federal Health Officials?

L. C. Peckham, Senior Sanitarian, Public Health Service, Chicago, Illinois

How Utilization of Added Solids-not-fat Concerns the City Health Official

Karl Mohr, Deputy Commissioner of Health, Green Bay

How the Use of Solids-not-fat Concerns Its Manufacturer

W. E. Uselman and Roger Hulbert, Galloway-West Company, Fond du Lac

The Status of Certification of Sources of Solids-not-fat for Use in Grade A Products

Clarence Luchterhand, Chief Milk Sanitarian, Wisconsin State Board of Health, Madison

Administration of the Grade A Milk Law in Wisconsin

Fred Griffith, Legal Section, Wisconsin State Department of Agriculture, Madison

Radioactive Fallout and Its Significance to Our Dairy Industry

Clyde Amundson, University of Wisconsin

Cheese Conference

THURSDAY, JANUARY 28

1:30–4:30

Room 205, Babcock Hall

STARTERS AND TECHNOLOGY

Chairman, Professor W. V. Price,
University of Wisconsin

Freeze-Dried Starters for Action

Don Eakle, Chr. Hansen's Laboratory, Inc., Milwaukee, Wisconsin

Frozen Starters in Factory Operations
R. S. Johns, Kraft Foods, Inc., Chicago, Illinois

Phage Preventative Media
Richard Kocher, Marschall Dairy Laboratory, Inc., Madison, Wisconsin

Developments in Starter Management Facilities
M. W. Hales, Klenzade Products, Inc., Beloit

Italian Soft Cheese in the New York Market
F. V. Kosikowski, Cornell University, Ithaca, New York

Heat-Loving Starters for Italian and Swiss Cheese
W. C. Frazier, University of Wisconsin

THURSDAY, JANUARY 28
6:30
Eagles Club, 1236 Jenifer St.
Wisconsin Dairy Technology Society Dinner
Speaker: Dr. F. V. Kosikowski, Cornell University, Ithaca, New York
Subject: The Irish, Their Dairying and a Wandering Professor

Ice Cream Conference
THURSDAY, JANUARY 28
1:30–4:30
Room 121, Babcock Hall

WINNING CONSUMER APPROVAL
Chairman, Professor C. A. Ernstrom, University of Wisconsin

Control of Raw Materials for Quality Ice Cream
Everett Byers, Bowman Dairy Company, Chicago, Ill.

Can We Improve Our Sherbets?
W. C. Winder, University of Wisconsin

Taste Panel—What About This Sherbet?
W. C. Winder and Conference

Recent Developments and Legislation of Significance to the Ice Cream Industries
B. L. Fisher, Executive Director, Wisconsin Milk and Ice Cream Products Association, Inc., Madison

Evaluating Consumer Acceptance
K. G. Weckel, University of Wisconsin

These are typical comments . . .

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we'll never get **GOOD SANITATION**

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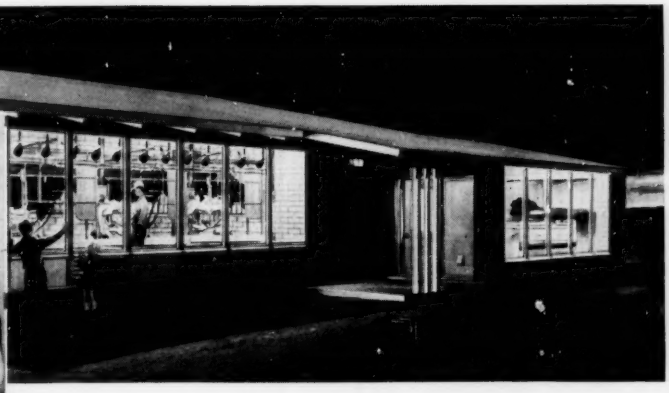
we'll never get **GOOD COW MILKING**

...without milking conditions that enable dairymen to take pride in their job

we'll never put **PRIDE back in DAIRY FARMING**

...without a milking setup that's built for the man...as well as for the milk and the cow



Unless the cow milker can take pride in his job, no dairy farm or milk plant can count on the kind of milk we all want for our children. For a free book, "The Way Cows Will Be Milked On Your Farm 'Tomorrow' " write —

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SACRAMENTO • SEATTLE • SYRACUSE • TORONTO

Program

Annual Wisconsin Dairy Plant Fieldman's Conference

January 28–29, 1960

THURSDAY, JANUARY 28

1:30–4:30

Union Theater, Main Auditorium, Southwest Entrance

CHANGES IN QUALITY CONTROL TECHNOLOGY

Chairman, Professor H. C. Jackson, University of Wisconsin

1:30 3A Sanitary Standards Development of Special Interest to Fieldmen
Clarence K. Luchterhand, Chief Milk Sanitarian, Wisconsin State Board of Health

1:50 Report on Chemical Sanitizers
Karl Mohr, Deputy Commissioner of Health, Green Bay, Wisconsin

2:10 Antibiotic Adulteration of Milk
F. V. Kosikowski, Cornell University, Ithaca, New York

2:50 Our Experiences in Determining Quality of Raw Milk
R. M. Parker, Milwaukee Health Department

3:10 Quality Improvement Progress in Neighboring States
E. O. Wright, Iowa State University of Science and Technology, Ames

3:40 Recent Legislation, Regulations, and Proposed Regulations of Special Interest to Dairy Plant Fieldmen
Don McDowell, Director, Wisconsin State Department of Agriculture

FRIDAY, JANUARY 29

9:00–12:00

Main Auditorium, Southwest Entrance

CHANGES IN MILK PRODUCTION TECHNOLOGY

Chairman, Professor M. P. Dean University of Wisconsin

9:00 Newer Methods of Milking
L. H. Schultz, University of Wisconsin

9:30 Panel Discussion—Experiences with Different Methods of Housing Dairy Cattle
C. K. Luchterhand, Wisconsin State Board of Health
Wm. Barthman, Farmers' Cooperative Creamery, Clear Lake
Russell Johannes, Branch Experiment Station, University of Wisconsin
George Werner, Stanley Witzel, and Wayne Thompson, University of Wisconsin

11:00 Panel Discussion—Cow Pools
Earl Wright, Iowa State University of Science and Technology
Sidney Staniforth, James Crowley, Edward Bruns, and Wayne Thompson, University of Wisconsin

HOW TO MAKE THE WORLD'S BEST ICE CREAM

You must use the finest dairy ingredients, the finest flavors, the finest mix processing and freezing equipment, the finest packaging—*And The Finest Stabilizer*—KELCO STABILIZER.

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Completed Theses

Ph.D. Degree

C. DAVIS—Acetate metabolism in ruminants. University of Illinois, Urbana.

R. FORREST—Some aspects of nucleotide metabolism in animal tissues and yeast. University of Illinois, Urbana.

E. FRAMPTON—The pathway of 2-metogluconate degradation in Pseudomonas fluorescens. University of Illinois, Urbana.

R. OPPERMAN—Pathways of methane production in the bovine rumen. University of Illinois, Urbana.

J. STAUBUS—The effect of fasting, phloridzin, insulin and butyrate on bovine energy metabolism as related to ketosis. University of Illinois, Urbana.

M.S. Degree

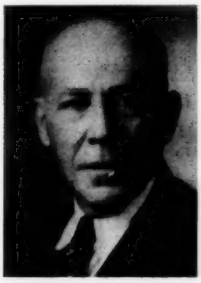
S. NETKE—Low-priced carbohydrates in milk replacers and effect of diet pH on fecal consistency in young calves. University of Illinois, Urbana.

BUSINESS AND INDUSTRY NEWS

Beatrice Foods Co.

The appointments of WILLIAM W. GRANGER, JR., as manager, and HENRY H. GOLDSCHEIDER as assistant manager, of the Baltimore, Maryland, Meadow Gold plant of Beatrice Foods Co. has been announced by WILLIAM G. KARNES, president of Beatrice Foods.

W. W. Granger, Jr.



H. H. Goldscheider

A veteran of 14 yr. of service with Beatrice Foods, Granger will serve as Division manager for all Meadow Gold ice cream operations in Maryland, the District of Columbia, and Virginia, in his new capacity. He also will continue as Manager of the firm's Washington, D. C., plant and as president of Meadow Gold Products Co., Washington, D. C. and Baltimore, Maryland.

Goldscheider, who has 33 yr. of experience with the company, has been named vice-president of Meadow Gold Products Co., Washington, D. C. and Baltimore, Maryland, as well as assistant manager of the Baltimore plant.

Swift & Company

From Swift & Company, Chicago, comes news that JOHN KITCHEL MCANELLY has joined their Dairy Research Division. Dr. McAnelly was awarded the Ph.D. degree in Bacteriology this year by the University of Wisconsin. His undergraduate work in dairy industry was done at Iowa State University, and he obtained his master's degree in Dairy Manufacturing in 1956 from North Carolina State College.

GARY H. RICHARDSON is also a new staff member of the Dairy Research Division. Dr. Richardson received the Ph.D. degree this past summer from the University of Wisconsin also, where his major was Dairy Industry. His undergraduate work, in Dairy Manufacturing, was done at Utah State University.

DAIRY TECHNOLOGY SOCIETIES

Atlanta—Reports one of the most enjoyable programs for a long time—December 7—in Pritchett's Restaurant (Decatur Elks Club). JOHN E. BEARDSLEY, G. O. Sales Engineer, The Creamery Package Manufacturing Company, Chicago, spoke on Automation of Cleaning Operations, illustrating his talk with slides.

Detroit—Annual Christmas Dinner (Ladies' Night) was held December 14 at Cregars Pickwick House. Featured speaker was SENATOR GUYER (Ohio). New officers elected for 1960 were: BRUCE BEVIER, president; WAYNE MARKER, vice-president; L. G. HARMON, secretary; DON MASELUS, sergeant-at-arms; BILL PETERS and BILL FORTH, directors.

Kansas City Area—This Society celebrated Christmas with a dinner-party on the evening of December 17. As usual, this was one of the outstanding events of their year—"plenty of enjoyment and fine, wholesome fellowship." On December 5 a dinner-dance was held at Moley's Ballroom.

Massachusetts—At their November dinner meeting, members had an opportunity to observe a portable automation cleaning unit in operation at the Needham Dairy. JOHN BEAM, of the University of Massachusetts staff, the main speaker, discussed the operation of this demonstration unit. JOHN BRAGG, also of the University staff, presented a brief summary of labor studies observed with this portable unit.

Minnesota—Dairy Plant Environment As a Sanitation Problem was the topic of the December 14 meeting, held at Worwa's Cafe in Minneapolis. Speaker was V. W. GREEN, School of Public Health, University of Minnesota. Problems of hospital environment were related to similar problems of the dairy plant in this talk by Dr. Green.

North Carolina—The North Carolina society heard FRED H. CALHOUN, Dairy Service, Inc., Lexington, speak on the topic of Management Controls—on what management is expecting of its employees in the future, especially in the way of controls—at its December 9th get-together at Huey's Seafood.

Philadelphia—Featured speaker at the Society's December 10 dinner meeting was HUNTER MCCARTNEY, Public Information Specialist of the Missile and Space Vehicle Department of the General Electric Company, Philadelphia. Dr. McCartney's talk included comments on life support in space, revolving around the subject of food and some of the problems which will present themselves as we move further along in our developments.

Tri-Cities—December meeting was held on the eighth at the Hillbrook Tavern. Highlighting this event was a speech by DR. DWIGHT SEATH, head, Dairy Department, University of Kentucky, on One Year in Ireland. His topic covered his experiences during his one-year teaching assignment in Ireland, illustrated with many slides.

Tri-State—A Christmas party was enjoyed December 16 at the Mona Lisa Lounge in Whitehall. As the Society's invitation stated, there were "no speakers, no reports, no business," but plenty of "social time, food, dancing, favors for the ladies, and door prizes."

NOTES

From the Secretary's Desk

1960 Membership—Dues notices were mailed out October 1 and your Secretary and his staff have been busily engaged counting their money for the last four weeks. As of November 11, the member record is 997 renewals, 32 new—total, 1,029. The S. A. record is 105 renewals, 85 new — total 190. While renewals have been coming in at a good rate, the speed will need to be maintained to get all 2,600 members into the fold by January 1, so keep them coming. It is expected that the Membership Committee will be working on new members and that they will be coming in at a faster rate in the near future. It is gratifying to note that members who have forwarded their dues have nominated 81 names for new members and that two Student Affiliate names have been nominated for this membership. This is a considerably larger number than was suggested during the entire membership campaign last year. The names of these prospective members have been mailed to the various State Chairmen.

H. F. Judkins

It would be very helpful if members whose dues are paid by the Treasurer of the com-

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Advertising Production Know-How Containers

HERE'S THE

NEW PRODUCT

YOU'VE BEEN LOOKING FOR!

Millions of packages already sold to date

YOU CAN BE IN THE DIP-N-CHIP BUSINESS PRACTICALLY OVERNIGHT just use your present equipment—stir the flavor into your sour cream and dig in for profits.

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Officially Approved for All Raw Milk Testing*

The NEW, accurate

TECHNICAL INDUSTRIES — TeSa — FORT LAUDERDALE, FLA.

BUTTERFAT TEST KIT

Replace old-fashioned methods and cumbersome equipment with the **TeSa REAGENT BUTTERFAT TEST KIT**

- ★ **SIMPLE!** Just mix, heat, temper and read! No centrifuge necessary!
- ★ **SAFE!** No dangerous acid used!
- ★ **ACCURATE!** Far more accurate in the field than any other method! Proved by University tests.
- ★ **ECONOMICAL!** Saves time, reduces labor and equipment costs. Can now be used for all butterfat determination in raw milk, subject to State regulations. Four sizes, Economy (for making 27 tests per hour), Dairyman (for making 36 tests per hour), Field Tester (for making 48 tests per hour) and Super (for making 60 tests per hour).

***Approved by American Dairy Science Association June, 1959 and adopted as first action for fat testing of raw milk by Association of Official Agricultural Chemists October, 1959, subject to State regulations.**

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Gentlemen: Please send me more information on the new TeSa BUTTERFAT TEST KIT and other TeSa products.

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essential in body processes

Among nutrients, proteins play a leading role in body processes...respiration, digestion, metabolism, reproduction, growth... and even awareness of and reaction to the world around us.

Each cell contains its own special proteins . . . made up of countless arrangements of about 25 different amino acids . . . combined to make some function possible. Some proteins work with vitamins and minerals as enzyme systems . . . breaking down food for energy and building material . . . then converting and synthesizing new substances needed for life and activity. Others form a wide variety of tissues with specialized functions . . . made possible by the nature of the proteins themselves.

The heart can beat to pump blood because the protein in muscle contracts and expands. Connective tissue holds the framework of the body together because the protein is elastic and acts like a taut rubber band. Eyes see . . . fear causes fright or flight . . . oxygen reaches cells . . . blood clots . . . wounds heal . . . all with the aid of specialized proteins.

The diet must provide the building materials for all vital proteins . . . 8 essential amino acids, preformed . . . and enough nitrogen to form all the others. These are most readily obtained from foods of animal origin . . . milk, meat, eggs, poultry and fish . . . combined in tasty meals with foods of plant origin . . . all kinds of grains in breads and cereals . . . vegetables and fruits.

Milk is man's first dietary source of protein . . . provided in desirable ratio with other nutrients with which protein works . . . carbohydrate, fat, essential fatty acids, vitamins, and minerals . . . to sustain growth and health in the infant while new functions are developing for adaptation to a new environment.

The nutritional statements made in this advertisement have been reviewed by the Council on Foods and Nutrition of the American Medical Association and found consistent with current authoritative medical opinion.

Since 1915 . . . promoting better health through nutrition research and education

NATIONAL DAIRY COUNCIL

A non-profit organization

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pany they work for would have the dues notice attached to the company check when it is sent to us. We frequently get company checks for $10 with no identification whatever; then we have to start corresponding, to see if we can find out whose dues are intended to be covered by the check.

Remember that new Student Affiliate dues must be paid by December 15, in order for them to get 15 Journals instead of 12. It is hard to understand why so many new Student Affiliate memberships are received every year after December 1, instead of before that date.

Dairy Science Abstracts payments (English) are coming in at about the same rate as last year. As of November 11, we received 337 from 1,029 members. We need 750 subscriptions and if they continue to come in at this same rate, we might have 750 by the time the membership campaign is over.

H. F. JUDKINS
Secretary-Treasurer

Public Refrigerated Warehouses Continue Educational Program on Good Handling Practices for Frozen Foods

To date, public refrigerated warehouses are the only segment of the frozen food business offering an industry-wide educational program on Good Handling Practices for Frozen Foods. The program is designed to present to warehouse operating personnel the latest scientific and practical information on how to protect frozen foods from temperature damage.

The Refrigeration Research Foundation of Colorado Springs, Colorado, directs and, through its Scientific Advisory Council presents, this educational program. The first of these Seminars was held in San Francisco, California, September 22 and 23. Fifty-four representatives of 19 public refrigerated warehouses on the West Coast attended. The next Seminar will be held in Chicago, January 28 and 29, 1960, with a third one in the New York City area early in February.

The Refrigeration Research Foundation is a nonprofit organization engaged in initiating and sponsoring scientific research at educational institutions and other food research installations.

The Foundation's research activities are supported by many public refrigerated warehouses, along with other segments of the food industry.

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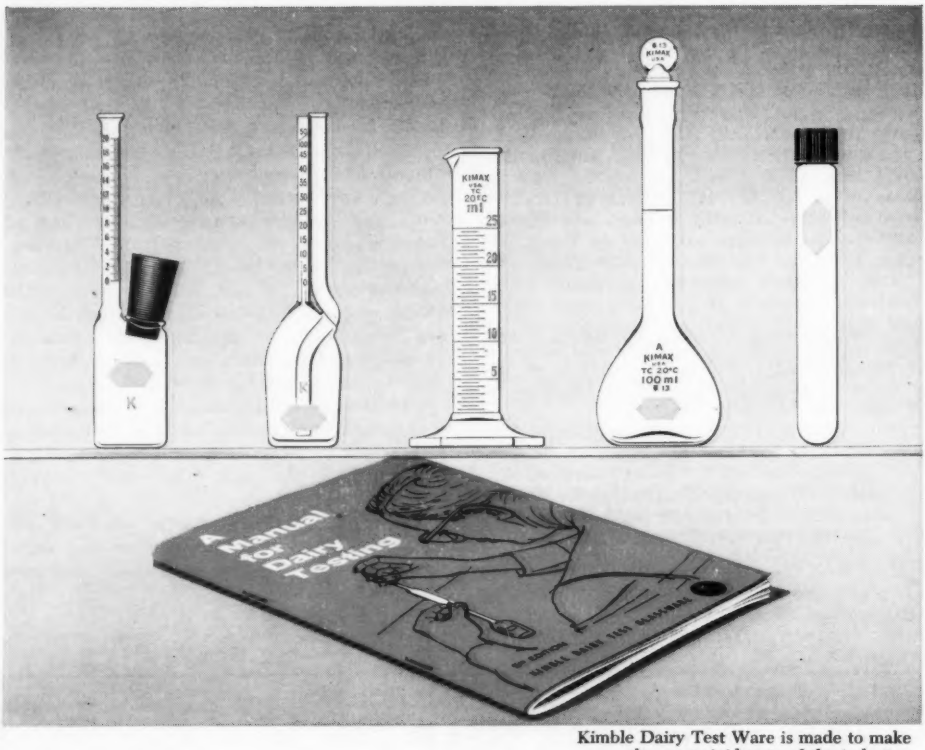

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STUDENT CHAPTER NEWS

J. E. JOHNSTON, Editor

A Section Devoted to News of Student Members

News of Student Activities

This section of the JOURNAL can function effectively only if the student chapters will send news of their activities to your editor. The section is intended to serve as a medium of exchange of ideas among student chapters and members. Such an exchange can help each chapter to improve its program. News should be mailed to: J. E. Johnston, Dairy Department, Louisiana State University, Baton Rouge 3, Louisiana, and should be in your editor's hands by the 5th of the month.

Kansas State Dairy Science Club

The Kansas State University Dairy Science Club held the first meeting of the fall semester Tuesday, September 22, 1959. BYRON WARTA, the club's representative at the annual A.D.S.A. meeting, told about the meeting, stressed its value, and suggested that a number of the members attend in the future. LEON SUCHT, the 1957 IFYE student to Panama, spoke and showed slides of the country. An activity planned for the future was a staff-student softball game. The club's first project of the semester was the furnishing of the evening meal on September 25 for those attending the Kansas Artificial Breeding Conference.

L.S.U. Dairy Science Club

"Have you had your milk—today?" That is what you will hear other students asked by members of the Dairy Club. They ask this question because the L.S.U. Dairy Science Club is organized to promote interest in dairying among students in dairying, and the promotion of the dairy industry in the state. Please don't get the idea that the efforts of all members are directed toward the ideal dairy cow.

Beginning the fall semester, the club had a Milk and Ice-cream Reception for freshmen interested in dairying and the Dairy Science Club. The persons interested in becoming members of the club were invited to a special meeting for an explanation of the functions and activities of the club. On Friday, October 30, these individuals were formally initiated into the L.S.U. Dairy Science Club, and simultaneously to various dairy products and additives. The young lady who joined the club was SANDRA LYNN GIROUARD, currently Louisiana Dairy Princess. Miss Girouard, along with VERNA JOHNSON, was nominated for the 1960 Darling of L.S.U. by the Dairy Club. Miss Girouard was selected from among the top 25 young ladies who were finalists in the contest.

The Dean of the College of Agriculture traditionally speaks each year to the club. DEAN J. NORMAN EFFERSON spoke on Fun and Facts with Figures. He had reference to keeping records on expenditures in the family budget. Do you know that a pair of socks cost 3¢ a mile? Is hunting the most expensive sport? Dr. Efferson said—Yes. This proved to be an interesting and factual talk.

The L.S.U. Dairy Science Club held its annual Christmas Party Friday, December 18. The party gave the members of the club the opportunity to meet some of the alumni of the club, and the faculty and staff of the Dairy Department.

The club prides itself on the activities and the services rendered to the department, university, dairy industry and, especially, on the activities promoting interest in dairying through F.F.A. and 4-H dairy judging contests held each spring.

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Kelco Co. 16
Klenzade Products, Inc. 7
Kraft Foods 9
Marschall Dairy Laboratory, Inc. 23
Mojonnier Bros. Company 11
National Dairy Council 20
The Nestlé Co., Inc. ..... Cover 3
Owens-Illinois Glass Co. 22
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Technical Industries 19
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WHEN ANSWERING

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SIGNIFICANCE OF STRONTIUM^{90} IN MILK. II.

A Review of Recent Data and Analysis of Areas Needing More Elaboration to Define the Role of Milk in the Diet

B. L. LARSON
Laboratory of Biochemistry, Department of Dairy Science, University of Illinois, Urbana

SUMMARY

Recent data are summarized in this second review article on the significance of Strontium^{90} (Sr^{90}) and other radioactive fallout in milk and other foods. This is followed by an analysis of areas needing more definition in the Sr^{90} problem. For a simplified review, the reader is referred to the Our Industry Today section in this issue of the JOURNAL.

The evidence now accumulating indicates that peoples in the primary milk-consuming areas are acquiring relatively lower levels of Sr^{90} in their bones than peoples in the primary plant-consuming areas. This is attributed to the high calcium level present in milk, protecting against the high levels of Sr^{90} accumulating in the foods of plant origin present in the human diet. Calculations show that for minimum deposition of Sr^{90} in human bones it may be just as wise to increase milk consumption as to try to remove the Sr^{90} from milk. The role of milk in the diet is discussed, and areas that need more clarification are delineated.

Since the previous review (17) was compiled a year ago, the importance of the Strontium^{90} (Sr^{90}) problem has been growing rapidly. The objective of this second review is to summarize the current situation. The review has been divided into two portions; the first is a presentation of recent data and the second is a discussion of how these data relate to the role of milk in the diet of people in the United States. The most logical way to discuss this second aspect is to list and discuss in some detail several problems associated with Sr^{90} that need more definition.

A simplified report on the Sr^{90} problem in relation to milk is also appearing in this issue of the JOURNAL OF DAIRY SCIENCE in the Our Industry Today section (18). In this simplified article, the Sr^{90} problem has been summarized briefly and some opinions and suggestions have been mentioned concerning the role of milk in the diet. These two articles should be considered with the background information in the previous review (17), in appraising the current situation.

A. REVIEW OF RECENT INFORMATION

The frequency of the accumulation and release of information on the importance of radionuclides in the food supply has increased rapidly in the past year. This includes data accumulated in previous years and released in completed form following the Congressional hearings of 1957 (31), as well as more recent data. Much of the information has suggested new areas requiring further investigation.

One of the greatest problems encountered, and yet the factor that has been stimulating the beginning of research efforts to solve some of the problems of

Received for publication October 14, 1959.

radiation, has been the interest of the public. It is unfortunate that the facts available still do not permit the formulation of intelligent decisions in all aspects of the long-term, low-level radiation problem; yet, there has been no shortage of opinions as to what should be done.

Milk has continued to bear the brunt of the public's opinion as being the principal source of radioactivity in their diet. This review is primarily concerned with milk and it is with respect to it that enough facts are beginning to accumulate to indicate its role in the diet in the Sr^{90} problem.

In this review, levels of Sr^{90} will be reported for the most part as strontium units. A strontium unit (S.U.) is a micromicrocurie ($\mu\mu$c.) of Sr^{90} per gram of calcium. Note that previously this same unit was more commonly called a Sunshine Unit.

Deposition of radioactive fallout. Initially, it was calculated that Sr^{90} blown into the stratosphere would take about 5–10 yr. for one-half of it to fall out (12, 20, 31). The rate of fallout since then has been more rapid and it appears that this prediction must be revised downward (5, 12, 20). This increased level of fallout over previously predicted levels has caused excitement in some quarters because Sr^{90} levels in foods have been increasing faster than the predicted rate (3, 13, 16, 29, 30). It must be remembered in this problem, however, that the stratosphere acts as a reservoir for Sr^{90} and, whether this fallout is quite rapid or slow, no more can fall out than was put there. If testing of atomic devices should continue at a more or less constant rate an equilibrium ultimately will be reached between that going up and that coming down. Calculations of the reservoir of bomb debris in the stratosphere recently have been revised slightly upwards, chiefly because of a recent series of Soviet Union tests of a high fallout nature. However, of the present total reservoir of Sr^{90} in the stratosphere, the United States and United Kingdom have contributed about three times as much as the Soviet Union (2, 3, 5, 7).

The global deposition of Sr^{90} has undergone considerable study and probably the largest factors controlling deposition are the size and location of the atomic tests, the winds associated with different latitudes, and the annual rainfall. Martell (20) and others (29) have presented data on the surface distribution of Sr^{90} in 1956, which showed that the Northern Hemisphere, chiefly around the 45th latitude, received a fallout level of about five times that of the 45th latitude in the Southern Hemisphere and about fifteen times higher than at the equator. This arises since atomic testing has occurred chiefly in the Northern Hemisphere. Eisenbud (12) has presented data covering a longer period (1955–59), which again indicate that the heaviest fallout in both hemispheres has been at about the 40–50th latitudes, but with the level in the Northern Hemisphere now about three times that of the Southern Hemisphere. Further predictions of these levels to 1965 have been made by Libby and Machta and have been recently summarized (5). This is shown in Figure 1. In general, the lowest levels are found at the equator and at the two poles. The effect of annual rainfall within a latitude, in general, determines how much will fall out in a given area (12, 20, 29). This rainfall contains some Sr^{90} (29), but the soil retains most of

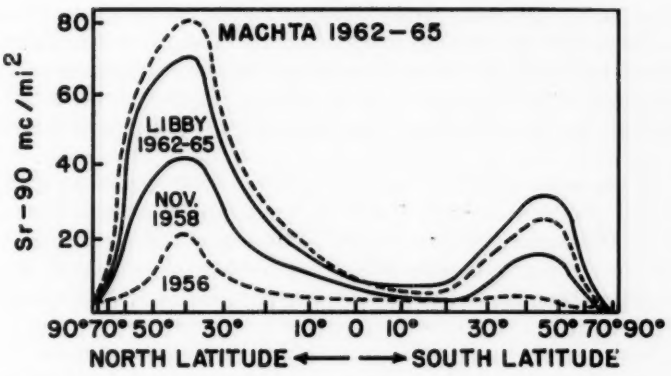

FIG. 1. The rate of fallout over the earth's surface as affected by latitude. The millicuries of Sr^{90} deposited per square mile are shown.

it and only a small portion eventually is found in rivers. Relative to other Sr^{90} sources, however, persons consuming cistern water (now averaging 3–5 $\mu\mu c.$ of Sr^{90} per liter) may be getting more Sr^{90} from this source than from milk and other foods; at least, water must now be considered as a source of Sr^{90} in the diet.

Bone levels of Sr^{90}. The recently published work of Kulp *et al.* (16) is of special note, relative not only to area fallout but to the levels of Sr^{90} that have been incorporated into human bone. This study is important because the actual bone levels of Sr^{90} are what man is really interested in keeping to a minimum. These investigators found that even though the fallout rate is much higher in the Northern Hemisphere than in the Southern, there are actually little differences in the bone levels. Data on the level of Sr^{90} in human bones are shown in Table 1. Kulp *et al.* (16) have advanced several reasons for this observation: (a) the high ratio of vegetable and cereal calcium to milk calcium in the diet of the Southern Hemisphere, (b) the higher rainfall of the local food-producing areas of the tropical regions (with extremely low calcium availability in some of these soils), and (c) the flow of food products such as wheat and powdered milk from the Northern to the Southern Hemispheres. Bones from the cereal diet (rice) areas of Thailand, Japan, and the Philippines were found to have a

TABLE 1

Levels of Sr^{90} in adult bones from 1955 through 1958. Number of samples is given in parentheses[a]

Location	Strontium units in bone		
	1955—1956	1956—1957	1957—1958
40–60° N	0.12 (177)	0.12 (176)	0.19 (111)
20–40° N	0.14 (88)	0.13 (114)	0.19 (44)
0–20° N	0.11 (130)	0.20 (63)	0.16 (101)
0–20° S	0.07 (41)	0.08 (22)	0.25 (16)
20–40° S	0.11 (88)	0.12 (78)	0.14 (90)

[a] Data taken from Kulp *et al.* (16).

level higher than the world average. In plotting the means of the present Sr^{90} levels in bones, and postulating from it future values, the data indicate that peoples in the areas of the world that receive their dietary calcium from milk and milk products are and will be accumulating relatively lower levels of Sr^{90} in their bones than those residing in the primary vegetable- and cereal-consuming areas.

The concentration of Sr^{90} in the skeleton of an average person in the world as of January, 1958, was about 0.52 S.U.; for adults about 0.19 S.U., and for children about five times that for adults. Considering only the present reservoir of Sr^{90} in the stratosphere, Kulp *et al.* (16) predict that a peak in bone levels will be reached about 1966, at which time average children will have about 4 S.U. in their bones.

The factors that control strontium deposition in the body and the possibilities of lowering it by using various agents to increase the elimination rate also have been under study. Lengemann *et al.* (19) have presented further studies on the enhancement of strontium absorption by lactose. However, as yet the effects of milk and various milk products in a normal human diet have not been worked out. More will be mentioned in the second part of this report on the effect of milk and milk products on discrimination against Sr^{90} by the human gut. Palmer *et al.* (24) have studied factors affecting the relative deposition of calcium and strontium in the rat, and have found that whereas the calcium content of the diet is the most important factor, the carbonate, phosphorous, and lactate levels can affect the deposition in the bone. The results can "hardly be said to clarify the situation," but they do point out that calcium availability alone does not explain all of the available data (24). These experiments reported on a short-term basis are at present being conducted on a longer-term basis. Wasserman and Comar (32) have presented data on the effectiveness of the calcium level in reducing strontium retention and report that the calcium to phosphate ratio in the diet, as well as the maturity of the animal, also are important factors.

Other work on the metabolism of strontium in man and animals may be cited, such as studies on the kinetics of the metabolism of strontium elimination and the use of various agents such as ammonium chloride and sodium citrate to stimulate its excretion (1, 11, 14, 24, 25, 27, 28). The whole area of the metabolism of strontium in relation to other mineral metabolism deserves more attention.

Hazards from radiation. It is not the object of this review to discuss the biological effects of radiation. The previous review (17) covered this area somewhat and the increased levels of radioactivity encountered in the past year have not materially changed the discussion and conclusions of that report. The United Nations' Scientific Committee on the Effects of Atomic Energy recently have published a long report on the fallout problem [for summary, see (6)]. As expected at this time, however, the report lacks conclusive answers as to what radiation means to man. *Scientific American* has recently devoted an issue to the subject of ionizing radiation and the articles by various authorities review well the current situation (26). Until more is known about the effects of long-

term, low-level fallout, the safest course to follow is that of trying to keep the concentration of radionuclides within our bodies to a minimum and then judging accordingly when more definitive facts are known. The levels encountered at present and in the predictable future, however, are low enough that they should not lead us to cease exploring the potentialities of atomic development, but all efforts should be made to gain the greatest possible information from a minimum number of these tests, if further testing is necessary, and to develop testing procedures that eliminate or reduce fallout to a minimum. [See (3, 7).] The development of underground and high-altitude testing procedures that practically eliminate earth surface fallout is a step in that direction.

Two groups, one national and the other international, have set permissible levels for the various radioactive materials with which humans will come in contact or will ingest in their food. In general, there is good agreement between these two groups. In foods, the elements that are of primary concern are Radium^{226}, Sr^{90}, I^{131} and, in special cases, some others, since these are special organ-seekers that accumulate in the body. Other elements such as Cesium^{137} (Cs^{137}) also are of potential importance, as they contribute to the tissue levels of radiation, but they do not accumulate in the body. Because of its long half-life and bone-seeking properties, Sr^{90} is probably the most important radionuclide resulting from nuclear detonations to consider in the long-term situation.

The National Committee on Radiation Protection (NCRP) has recently revised permissible levels for atomic workers (4, 23). The permissible bone burden of Sr^{90} was doubled from 1 to 2 μc.; whereas, the level for Cs^{137} in muscle was cut almost in half, from 90 to 50 μc. NCRP recommends that the levels for the public in areas neighboring controlled areas be one-tenth those of occupational exposure. It is interesting to calculate that a permissible level of 2 μc. of Sr^{90} is about equal to a 2,000 S.U. permissible bone level in atomic workers and 200 S.U. in the bones of people neighboring such areas. This should be compared with the present level of about 5 to 50 S.U. in our present diets, which is discriminated against by a factor of one-fourth to one-half before it is deposited in bone, and the present permissible level in bone of 100 S.U. for the whole population. The recommended permissible levels undoubtedly will be revised as time proceeds and more definitive facts are known.

This review is concerned primarily with Sr^{90}; however, in certain areas, Radium^{226} from natural sources may be more of a problem than Sr^{90}. Where Radium^{226} deposition makes up a significant part of the radiation received in bone, the Sr^{90} permissible level is proportionately lowered, so that the combination of the two does not exceed the permissible total level of bone radiation.

There has been an increasing tendency on the part of agencies collecting data on Sr^{90} levels in foods to report the results in absolute terms, i.e., the $\mu\mu$c. of Sr^{90} per unit of volume or weight, instead of on a strontium unit basis ($\mu\mu$c. of Sr^{90} per gram of calcium). This procedure of reporting data has many advantages, but it also has a serious shortcoming in data interpretation, in that it puts the major emphasis on reducing the total amount of Sr^{90} in the diet without considering the bone levels of Sr^{90} that may result. This, of course, is

not true if the calcium level in the diet is considered also. Milk, for example, contains ten times as much calcium as do potatoes. Thus, even if the absolute levels of Sr^{90} in milk and potatoes are the same, a diet of potatoes can deposit five to ten times as much Sr^{90} in bones as a diet of milk. Thus, great care must be exercised in evaluating data and one must know the basis of the units being used. The ramifications of reporting Sr^{90} in terms of absolute amounts versus strontium units are further discussed in the second half of this report.

Testing programs for radionuclides in foods. A significant release of data in the past year are the reports (29) of the Health and Safety Laboratory of the Atomic Energy Commission (AEC). These contain data collected in the monitoring of long-range fallout. Values are tabulated from AEC and from United States Public Health Services (USPHS) data, Lamont Geological Laboratory, United Kingdom Atomic Energy Research Establishments, and various other U.S. and foreign sources on fallout deposition, air concentrations, water concentrations, and the amounts in human food and bone. Results are given for several experimental investigations and, although interpretations are not given for most of the data, certain papers included do attempt to interpret the present situation. Much of the data concerns various milk studies, including accumulated values on Sr^{90} levels in milk from various locations, variations within a milk supply from a given area, pasture studies, etc. In general, the reports summarize the available data up to 1959 and must be interpreted as such; some of the interpretations in the earlier reports no longer are completely valid.

Most of the testing now going on for radionuclides in foods still is concerned chiefly with milk, and improved methods for testing milk have been devised (21, 22). Several agencies now are concerned with radionuclide levels in other foods (2, 13) and it is hoped that within a reasonable period more data on other foods will be available. In addition to the AEC, USPHS, and the Food and Drug Administration (FDA), other locations in this country, as the University of Chicago, Lamont Geological Observatory of Columbia University, the New York State Department of Public Health, and various foreign locations in Britain, Norway, Germany, Japan, and other countries, are busy determining levels of radionuclides in milk and in some other foods. An independent agency, the Consumers Union, also conducted a survey on milk, and its report on the radiation problem, in general, is one which all interested in this problem should read (9).

Current levels of Sr^{90} in milk. In general, the results have shown that the levels of Sr^{90} in milk have been increasing steadily in relation to the over-all accumulation of radioactive fallout. Mid-1958 values range between 3 and 14 S.U. in the USPHS reports and from 2 to 16 in the Consumers Union study (9). The levels in some of the cities included in the survey are shown in Table 2. Wide differences are seen in the levels and it is difficult to draw concrete conclusions. Monthly fluctuations in any location reflect to a great degree the rainfall during the previous month. Milk from the southwestern part of the country tends to contain less Sr^{90} than the average. The two reports do not agree as to which cities have the highest or lowest levels. This is attributed to sampling differences and statistical errors because of the difficulties in analyzing the low levels

TABLE 2
Some levels of Sr^{90} in milk

	Consumers Union	United States Public Health Service	
	(July-August, 1958)[a]	(July-August, 1958)[a]	(1958—1959)[b]
		Strontium Units	
Alabama, Birmingham	7.4		
Alaska, Juneau	4.9		
Arizona, Phoenix	3.3		
California, Los Angeles	1.9		
California, Sacramento		4.6	5.0
Colorado, Denver	5.9		
Florida, Miami	4.6		
Georgia, Atlanta	7.9		
Illinois, Chicago	12.6		
Louisiana, New Orleans	15.6		
Massachusetts, Boston	13.9		
Minnesota, Minneapolis	9.2		
Missouri, St. Louis	11.1	13.4	15.1
New York, New York	10.5	6.5	6.7
Ohio, Cincinnati		9.4	9.8
Texas, Austin	2.5	3.0	
Utah, Salt Lake City	5.2	4.1	4.5
Canada, Quebec	13.6		
Canada, Winnipeg	9.5		

[a] Selected data from (9).
[b] Average for 12-mo. period ending in February of 1959 (29). See text for some more recent 1959 values.

present. It is remarkable that the two surveys agree as well as they do. Thus, the mid-1958 levels of Sr^{90} in milk vary widely, but seem to average about 8 S.U.; 1959 levels in the United States probably average about 10 S.U. Various reasons have been advanced to explain these area differences, such as differences in fallout rate due to latitude, winds, rains, calcium availability in the soil, and type of forage and water available for dairy cows. This is discussed more fully in the second part of this review.

At different times in several locations, the level of Sr^{90} in milk may reach levels three to four times the average over the country. Calculated on the basis of the $\mu\mu$c. of Sr^{90} per liter of milk as a unit, USPHS data for the last quarter of 1958 show levels in milk in St. Louis reaching 20 units in November and 15.6 in December, for a yearly average of 13.2 (3); 1959 values in St. Louis include 37.3 in April, dropping to 11.2 in June (6). AEC data (9) show that milk in the Mandan, North Dakota, area contained 32.7 units in August of 1957 and 26.8 in July, 1958. It should be noted in the Consumers Union report (Table 2), however, that New Orleans, Chicago, Boston, and Quebec in Canada had levels expressed in strontium units above those found in St. Louis in mid-1958 and in June of 1959. USPHS data, expressed as $\mu\mu$c. per liter, also show Atlanta, Fargo-Moorehead, and Spokane above St. Louis (8) in mid-1959. It should also be noted that milk from St. Louis contains more calcium than milk from other cities included in the 1958 USPHS testing program. St. Louis milk averages 1.2-1.3 g. of calcium per liter, whereas in the other cities (i.e., Sacramento, Salt Lake City, Cincinnati, and New York) it averaged 1.0-1.2 (10).

These levels in milk should be compared with levels found in other foods that contribute to the calcium and the Sr^{90} intake in our diets, so as to assess the role of milk in the diet.

Current levels of strontium^{90} in other foods. Data on the Sr^{90} content of other foods are still few. There has been no intensive program to monitor foods in different parts of the country as there has been for milk. However, recent data have indicated that Sr^{90} levels in other foods are increasing so rapidly relative to milk that several agencies (i.e., USPHS and FDA) are now beginning to intensify such programs (2, 13, 29). The scope and intensity of this monitoring is not known as yet, but the limited data available indicate that now it is probably more important to examine these other foods than to examine milk.

It is possible to draw conclusions as to what the current levels of Sr^{90} are in the plant portion of our diet (cereals, vegetables, fruits, nuts, etc.) by extrapolating back from current levels in milk and human bone. Such extrapolations indicate that the current levels of strontium units in the plant portion of our diet probably average five to twenty times as high as the levels in milk and may well be higher in certain areas.

Data released by the AEC for pooled samples of the 1958 wheat crop from nine of the wheat-growing states (Illinois, Kansas, Michigan, Minnesota, Montana, New York, North Dakota, Oklahoma, and Texas) indicate a level of 64 to 330 strontium units (3, 29). This represents a level of about six to 30 times greater than the level present in milk produced in these states. For example, the level present in New York State wheat was about 12 times that present in New York City milk, the level in Illinois wheat was about 25 times that present in Chicago milk and about 15 times that present in St. Louis milk, the level in Minnesota wheat was about 17 times that present in Minneapolis milk, etc. A further indication of the plant contamination level are the studies by the FDA indicating a level of 136 to 806 $\mu\mu$c. of Sr^{90} present per kilogram in some individual samples of alfalfa from Maryland, Minnesota, Nebraska, and South Dakota (13).

The USPHS recently made a survey of the Animas River Valley in Colorado and New Mexico (30). The primary purpose of this was to study radium levels resulting from river pollution from a uranium refinery; however, when Sr^{90} levels from fallout were found to be extremely high, the Sr^{90} contents of foods in the area were more intensely determined. Calculated on a strontium unit basis, using average calcium values for these foods (15), the following values are typical of those found: 5 in milk, 210 to 682 in cabbage, 37 to 50 in potatoes, 1,137 in peas, 34 to 200 in sweet corn, 110 in apples, 86 to 4,420 in lettuce, etc. It should be noted that food produced for cattle consumption in the same area (alfalfa, wheat, and oats) averaged less than 10 S.U. On the average, the foods of plant origin consumed by humans averaged about 40 to 60 times higher in strontium units than did milk, with milk contributing only about 10% of the Sr^{90} in an average diet. Other extremely high levels have been reported from time to time in other areas. The present data suggest that the levels of Sr^{90} in plant foods are well above those present in milk, and so far above, that even though each plant source contributes a small proportion of the total food humans

consume collectively, they are contributing more Sr^{90} to the diet than is milk. The significance of these values will be discussed in the second half of this review.

Conclusion. The most significant aspect of the data released during the past years is that they are beginning to confirm the previous predictions (17), that the high calcium level in milk is the agent in the diet which will help reduce the relative bone deposition of Sr^{90}. A further discussion of this in relation to the many problems that need to be resolved before the role of milk in the Sr^{90} problem is completely understood will follow in the second part of this paper.

B. AREAS NEEDING MORE DEFINITION

One of the purposes of any review article is to acknowledge areas of a field that have been both well and poorly defined. It is not difficult in this review to point out areas that need further investigation, since the complete field of radioactivity, by virtue of its newness and wide scope, needs elaboration in all areas. Understandably, differences of opinion arise with any such evaluation; however, several problems in the area of radioactive fallout and milk, specifically, are noteworthy of special mention and an attempt will be made to discuss their pertinence. This will be done, not necessarily in the order of their importance but in the order of a more logical discussion.

(1). *The effects of long-term, low-level radiation on humans.* Does ingestion of Sr^{90} (and other radionuclides) induce harmful effects, and to what degree, at what levels? This is the crux of the problem. If the effects of long-term, low-level radiation can be considered negligible at the present and predicted levels of Sr^{90} in foods, then no problem exists. Only when enough time has elapsed to find answers to the many problems here will we really know how serious the problem is. Even though the present evidence suggests that the present and projected levels are minor compared to radiation received from natural sources and through medical practices, still we must assume it to be a problem until more definitive data are available to judge intelligently the relative merits of any disadvantages of radiation and the advantages of atomic energy utilization (3, 17). Accordingly, at this time, means of reducing our Sr^{90} intake must be investigated and all steps taken to reduce it as low as possible.

(2). *Means by which Sr^{90} gets into milk.* The dairy cow in assimilating feedstuffs into milk discriminates against Sr^{90} by a factor of about seven to eleven, due to discrimination by the gut, the kidneys, and the mammary gland. But the feed of a cow is supplemented with calcium from rock sources and bone meal, so actually the animal is probably discriminating against total Sr^{90} in the plant portion of its feed by a factor between ten and 20. The Sr^{90} content of milk can be decreased if it is possible to increase the discrimination between plant feedstuff and milk. One can postulate several means by which this might be accomplished: (a) It may be possible to increase the level or ratio of metabolizable calcium in the diet of the cow by using more rock-source calcium, coupled with other appropriate minerals or compounds (rock-source calcium contains little or no Sr^{90}, as opposed to bone meal with some), or (b) it may be possible to reduce the Sr^{90} content of the plant food of the cow. Investigations of this type

into the effect of rock versus bone meal and plant calcium sources, effects of adding certain substances to the diet to enhance discrimination, the merits of favoring forage crops taking up less Sr^{90} than others, soil care, including the plowing and liming of pasture land, the effects of rainfall and climatic conditions, etc., all bear promise as means of reducing the Sr^{90} level in milk. Some of these possibilities probably explain some of the area differences found today in the survey testing programs for Sr^{90} levels in milk. More investigations of this type are needed as to how Sr^{90} gets in milk and, knowing how it gets there, developing means by which it can be reduced.

(3). *Means by which Sr^{90} gets into other foods.* Investigations such as mentioned in (2) are probably even more pertinent to study means of reducing the Sr^{90} levels in other foods, notably of plant origins. Surface fallout can be removed by washing and peeling many plant foods; however, as time proceeds, more Sr^{90} is moving into the soil and more is being incorporated internally by plants. The favoring of certain crops, proper soil care, and preparation for consumption are possibilities for lowering our Sr^{90} intake from plant sources. Since this review is concerned chiefly with milk, this will not be elaborated on further.

(4) *The role of milk in the diet in the Sr^{90} problem.*

(a) Human discrimination against Sr^{90} in milk. In consuming food containing Sr^{90}, the human body discriminates against it at two major sites, the gut and the kidneys. Each of these sites is responsible for about a 50% reduction in the strontium unit level. The potential level of strontium units that can be deposited in the bones is about one-fourth that present in the diet. The actual amount deposited depends on such factors as the total available or metabolizable calcium level in the diet and the age of the person, i.e., how much new bone is being formed and how much exchange of calcium with Sr^{90} is taking place in the existing bone. There is good evidence that certain substances, notably lactose, enhance strontium absorption by lowering the discrimination by the human gut, leaving only the discrimination by the kidneys. This point is very much in doubt as far as the effects of milk in a normal diet are concerned. Limited studies can be cited (17) to support a discrimination factor of two in humans between diet and bone on an all-milk diet but, in general, population studies (16, 17) have indicated that a factor of four must be operative for the primary milk-consuming nations. Milk gains its eminence over other foods in lessening relative Sr^{90} absorption because it contains a high calcium level and because the cow has already discriminated against the Sr^{90}. However, if on consuming a high milk diet the presence of lactose lessens the discrimination in the gut, then part of the advantage of consuming milk has been lost. The possibility strongly exists that certain dairy products without lactose, such as cheese and cultured milks, may allow the full discrimination by the gut to occur; whereas, other forms, notably fluid milk, may lessen the discrimination. This is of prime importance in considering the matters discussed in the next section. Further studies on this discrimination are needed, relative both to the effect of the gut in discriminating against specific dairy products and, ultimately, to dietary recommendations for the population in general.

(b) The ratio of strontium units in other foods to those in milk. Calculations on the levels of Sr^{90} that are present in other foods of plant origin indicate that even though they contribute only one-tenth to the calcium diet of the American public they may be contributing as much and, in some instances, ten or more times as much, Sr^{90} to the diet as the milk portion. It is imperative to continually assess the levels in plant foods consumed by humans. Data collected in previous years are somewhat misleading, in that they show a wider difference than actually exists as time proceeds between Sr^{90} levels in plant foods consumed by cows and those consumed by humans. Some of these variances are, of course, due to differences in the types of plants that humans and cows consume. Many of the plants are similar, however. Initially, most of the Sr^{90} associated with plant materials was due to surface contamination and this could be removed in the processing of such foods for human consumption. As time proceeds, however, the level of Sr^{90} is accumulating in the soil and is being incorporated internally by many plants. Surface contaminat ''len, is becoming an increasingly smaller proportion of the total amount present in the plant foods. Recent data indicate that the range between the levels in plant foods for human, and those for cattle, consumption is becoming smaller.

Persons in the United States receive an average of 10% of their calcium supply from plant foods and 85% from milk. The remaining 5% comes from animal sources such as meats and eggs and, in general, their Sr^{90} levels in terms of strontium units are between milk and plant foods, probably being closer to milk. If the levels of Sr^{90} in the plant foods consumed by the cow average about one and one-half times those present in the plant foods consumed by humans, then the plant food portion of the American public's diet contributes as much Sr^{90} as comes from milk. If, on the other hand, the plant foods consumed by the cow contain no more Sr^{90} that that consumed by humans, then milk will contribute only about one-third of the Sr^{90} consumed by the average American person. Another way of stating this is: if the ratio of the strontium units in the plant portion of our diet to the strontium units in milk is greater than one, the strontium units in the diet can be decreased by increasing milk consumption. If the ratio is greater than ten, then we consume more Sr^{90} from the plant portion of our diet than we do from milk.

It is difficult to express these concepts in simple terms, especially because knowledge in all areas pertinent to the problem is incomplete. However, one of the reasons milk has received so much publicity in the Sr^{90} problem has been the lack of an adequate means of expressing its role in the diet relative to other foods. The problem is compounded by the fact that the highest absolute levels of Sr^{90} tend to be found in the foods that contain the most calcium; yet, from a physiological standpoint, it is these foods that provide the majority of the calcium in the total diet that allows discrimination to occur against Sr^{90} in its pathway to the bones. In the United States, the major dietary source of calcium is milk; in some other countries, it may be wheat or some other source. Since a high calcium food can contain the highest absolute level of Sr^{90} of any item of food in the diet, and yet removal of this food from the diet actually causes more Sr^{90}

to deposit in the bones because the ratio of Sr^{90} to calcium in the resultant diet is smaller, a fair means of expressing the role of this food in the diet is necessary.

Because of these considerations, the author has found it helpful to define and use what is called the Plant/Milk (or P/M) ratio in considering the role of milk in the average diet in the United States and as an index to express the relative contamination of milk versus other foods in the diet.

This is defined as the ratio of the strontium units in the collective foods of plant origin in the human diet to the strontium units present in milk.

$$\text{P/M ratio} = \frac{\text{Strontium units in plant portion of human diet}}{\text{Strontium units in milk portion of human diet}}$$

The strontium units in the plant portion must be evaluated by assessing the amount of Sr^{90} and calcium contributed by each plant food and, thus, it represents the total contribution from the actual amount of each food that would be present in an average diet. It is apparent that because of differences in food-consuming habits and the difficulty in calculating this ratio, it is of little use to the individual person. The P/M ratio is of use for assessing the contamination of milk relative to other foods and in assessing the proper role of milk in the diet for the whole country, or in an area of the country where a figure for the strontium units in the plant portion of the average diet can be evaluated. Knowing the proper role of milk in the diet, it is then possible to make intelligent decisions as to whether it would be advisable to remove either milk or some other food from the diet or whether attempts should be made to remove the Sr^{90} from these foods.

It is not known with a confident degree of certainty what the current levels of Sr^{90} are in the foods that we consume other than milk. However, a summary of the data released up to 1957 indicates that the average P/M ratio was two to three (17). More recent data have indicated that the level is rising rapidly and now probably averages for the United States somewhere between five and 20. For example, using alfalfa and wheat as an index of plant contamination, a P/M ratio of ten to 20 or over is indicated in a good part of the United States. Late 1958 values for milk were 5 S.U. in the Animas River Valley of Colorado and New Mexico, but the Sr^{90} present in human plant foods grown in this area was reported as averaging much higher, to give a P/M ratio of about 40. It must be remembered that the milk came from cows also consuming plant foods produced in the same area.

Reference to Figure 2 will show the necessity of more accurately assessing the P/M ratio of the average American diet. If the P/M ratio is 15, an average diet will contain 24 S.U. However, a person consuming half the average of milk has about 40 S.U. in his diet, and a person consuming no milk has up to 150 S.U. in his diet, as well as probably being on a calcium-deficient level. On the other hand, a person doubling his milk consumption would have only 15.5 S.U. in his diet. Note that at a P/M ratio of 15, the strontium units in the diet can be reduced just as effectively by doubling milk consumption as by removing all of the Sr^{90} from milk. Even if the P/M ratio were nine and it were possible to

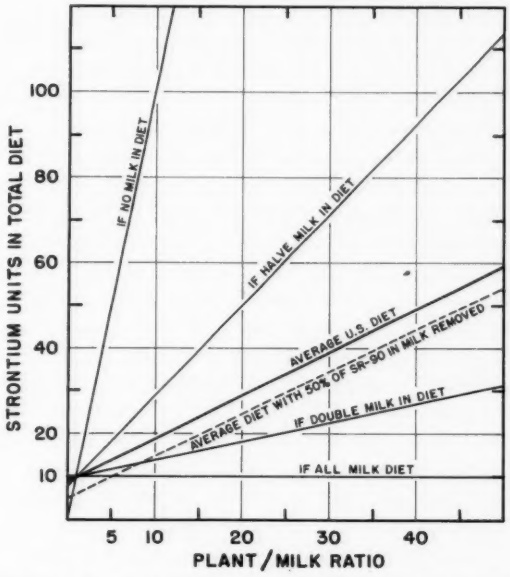

FIG. 2. The effect of the P/M ratio (strontium units in plant portion of human diet to those in milk portion) on the relative dietary intake of Sr^{90}. This figure shows values assuming milk contains 10 S.U. If milk contains 20 S.U., every value should be multiplied by two; if five S.U., then by 0.5, etc. The conclusions remain the same. It is assumed in calculating this figure that the normal pint of milk (or milk products) consumed per person per day in the United States contributes 90% of the dietary intake of calcium, with foods of plant origin contributing 10% (see text and Table 3). When it is reduced to ½ or increased to 1 pt. per day, it is assumed that the normal plant portion of the diet is inversely increased or decreased 20%, so that the caloric intake stays about the same.

remove easily 50% of the Sr^{90} from milk to give 13 S.U. in the total diet, by doubling milk consumption the level could also be reduced to 13 S.U. Calculations raising other possibilities can also be made; for example, if the P/M ratio is five, the addition to the average diet daily of 0.8 g. of metabolizable calcium from rock sources, either separately or added to an item of the diet such as the cereal portion, is just as effective as removing 90% of the Sr^{90} from milk. If the P/M ratio is ten or 15, 0.5 and 0.3 of rock-source calcium, respectively, would accomplish the same purpose.

These considerations of raising the dietary calcium level by increasing milk consumption or adding rock-source calcium must take into account the possible disadvantages resulting from this calcium intake. From a medical standpoint, more harm might result from calcium deposits within the body than from cancer possibly resulting from Sr^{90}. A small increase in the average population intake of calcium might do no harm, and a greatly increased consumption for short periods such as during pregnancy or by the baby after birth, or following a nuclear attack, might be entirely appropriate.

The suggestion to increase milk consumption also suffers from the possibility that on a high milk diet the discrimination against Sr^{90} by the human gut may be reduced. However, the evidence suggests that this would not be the case, since milk is consumed mixed with other foods and especially if such milk consumption were in the form of dairy products from which lactose has been removed.

The lowering of discrimination by the human gut on an all-milk diet raises the question of new bone growth in babies consuming such a diet. If the discrimination by the gut is eliminated, the effective level of strontium units in milk is doubled as far as the bone deposition level is concerned. Even so, reference to Figure 2 will show that an effective level of 20 S.U. from an all-milk diet is no more than an adult would receive on a normal diet, if the P/M ratio is ten, or one-fifth of what a person consuming no milk would receive. Adding metabolizable calcium from rock sources (appropriately balanced with phosphate, etc.) at a level equivalent to the calcium present in the milk would probably be just as efficient as removing 50% of the Sr^{90} from milk in the first place.

At the present time, there is insufficient information to accurately assess what the actual role of milk is in the diet. Accurate data on the possibilities raised here are vital to define the position of milk in the Sr^{90} problem. The evidence already indicates that the American public will be accumulating relatively less Sr^{90} in their bones than the non- or reduced milk-drinking peoples. The data suggest that increased milk consumption is a means of further lowering the level of Sr^{90} deposited in our bones. The degree to which these conclusions hold true depends primarily on the Sr^{90} levels present in the other foods humans consume. These levels need to be accurately determined, not by looking at past data but by assessing the values as time proceeds.

(c) *Assessment of the relative importance of Sr^{90} intake versus bone deposition levels.* The available evidence indicates that the ratio of the amount of Sr^{90} to the calcium present (strontium units) in a diet determines the ultimate bone deposition level that can occur. In the ultimate analysis, it is the level of Sr^{90} deposited in bone that is the primary concern in the Sr^{90} problem, since the soft tissue irradiation from Sr^{90} is of no consequence in comparison to the levels received from other man-made and natural radionuclides present. A diet containing Sr^{90} but high in calcium can lead to lower levels deposited in the bone than a diet containing less Sr^{90} but also deficient in calcium. Most agencies and research groups have reported and compared analyses on foods in terms of strontium units (micromicrocuries of Sr^{90} per gram of calcium). Such a system suffers from the fact that some foods may be low in Sr^{90} but extremely low in calcium, so that an abnormally high strontium unit figure results which is of little significance (water is an example). Also, only very small amounts of some foods are consumed and a high content of strontium units means little as far as the contribution in the total diet is concerned (spices, for example). For these reasons, more recently some agencies have tended to report analyses in terms of the actual amount of Sr^{90} present (micromicrocuries of Sr^{90} present per unit of weight or volume). In this way, the total $\mu\mu$c. of Sr^{90} consumed per day can be readily computed and compared to the daily intake of other radionuclides.

Unfortunately, this system also has some shortcomings for reporting data, as the absolute $\mu\mu$c. present tends either to ignore the level of calcium in the diet or to relegate it to secondary importance, and this leads to interpretations which make no allowances for the subsequent bone deposition levels of Sr^{90} that can result. For example, if milk contains 11.3 $\mu\mu$c. of Sr^{90} per liter (10 S.U.) and the P/M ratio is 15, a person consuming a normal diet would consume 14.4 $\mu\mu$c. of Sr^{90} per day. This diet could lead to a bone level of 6.5 S.U. If this person stopped drinking milk, he would drop his Sr^{90} intake to 9.0 $\mu\mu$c. per day, but this diet would lead to a bone level of 37 S.U. Thus, in dropping the daily Sr^{90} intake from 14.4 to 9.0 $\mu\mu$c., the potential bone deposition is raised from 6 to 37 S.U. Now, a baby on these diets indefinitely would probably accumulate 6 and 37 S.U., respectively, in his bones. However, an adult would not, since his bones were previously formed. Kulp *et al.* (16) have estimated that the exchange rate of total bone calcium with dietary calcium (containing Sr^{90}) in adults is about 3.8% per year. Thus, average adults, having 1,000 g. of calcium in their bones, would have accumulated in a year on the two diets, one with and one without milk, 228 and 1,406 $\mu\mu$c. of Sr^{90}, respectively. Now, the person receiving 14.4 $\mu\mu$c. per day in his diet gets radiation every day from this, plus 228 $\mu\mu$c. in the bones, or a total of 242 $\mu\mu$c. The person on the 9.0 $\mu\mu$c. per day diet gets radiation from this, plus 1,406 $\mu\mu$c. in the bones, or a total of 1,415 $\mu\mu$c. The difference becomes cumulatively larger as time goes on. The person on the lower Sr^{90} diet containing no milk will be receiving six times as much radiation per day from Sr^{90} as a person on the higher Sr^{90} diet, containing milk.

The important point illustrated in these calculations is that the actual changes in the $\mu\mu$c. of Sr^{90} present in the diet are irrelevant; whereas, the changes in potential bone deposition level of the Sr^{90} present are important. Thus, a lowering of the $\mu\mu$c. of Sr^{90} in the diet will accomplish nothing, or make the situation worse, unless the calcium level in the diet is maintained.

The unfortunate aspect about the current situation is that the American public has been led to believe that milk is the principal food leading to Sr^{90} deposition in their bones. Thus, when the public is told that it is important to reduce the $\mu\mu$c. of Sr^{90} in their diet, the first thing they think of eliminating is milk. In so doing, then, the basic assumption that calcium intake must remain the same, no longer is true.

The permissible level of daily Sr^{90} intake has been set at 176 $\mu\mu$c. (23). This level has been arrived at by taking the permissible level for water of 80 $\mu\mu$c. per liter and assuming 2.2 liters are consumed per day. The same level for water now is being used to apply to foods such as per liter of milk or kilogram of solid foods. The permissible level for water was originally derived by calculating from the best data available the amount of ingested Sr^{90} that will deposit in bone. To be on the safe side, the permissible level for the population was set at less than one-hundredth the amount that might produce cancer in some individuals. However, the permissible daily intake level of Sr^{90} intake expressed as $\mu\mu$c. ignores the tremendous dependency on maintaining the calcium level in the diet, and this is especially true as the P/M ratio increases in magnitude. At a P/M ratio

of one, it does not matter whether the Sr^{90} comes from milk or from plant sources, for the bone deposition power will be the same. At higher P/M ratios, however, the greater the contribution of plant-source Sr^{90} to the diet, the more bone deposition of Sr^{90} will occur, even though the same number of $\mu\mu c.$ of Sr^{90} may be present in the diet.

To illustrate some dietary calculations, a diet is shown in Table 3 in which it is assumed different levels of Sr^{90} are present in various foods. Meat is included in this diet, but it is neglected in calculating the P/M ratios. In Case I, all of the foods contain the same level of strontium units; in Case II, all of the foods contain the same $\mu\mu c.$ of Sr^{90} per kilogram; and in Case III, more typical values are shown. All of the values used in Case III are either similar to or lower than actual values that have been reported. In each case, the contribution of each food to the total calcium intake and the total Sr^{90} intake has been calculated. The total $\mu\mu c.$ of Sr^{90} have been then summed up and divided by the total calcium level in the diet. It is important to note the magnitude of the contribution of milk to the calcium in the diet, compared to all of the other foods (see footnotes to Table 3).

In Case I, the P/M ratio is one and milk is contributing 85% of the total Sr^{90} to the diet. It does not matter what foods are included, for the strontium unit level is the same. However, note the low $\mu\mu c.$ of Sr^{90} per kilogram in the other foods. For other foods to be comparable to milk (all 10 S.U.), their level of $\mu\mu c.$ of Sr^{90} per kilogram must be much smaller.

In Case II, the $\mu\mu c.$ of Sr^{90} per kilogram is the same for all foods, and the P/M ratio is about ten. When values are reported as the $\mu\mu c.$ present, the tendency is to compare them on this basis; however, note now that milk is contributing only 35% of the Sr^{90} in this diet and that the strontium units in the other foods range six to 20 times higher than in milk. If milk is excluded from this diet, the strontium units in the total diet increase over four times (87 S.U.) those present when milk is included (20 S.U.).

In Case III, the P/M ratio is about 28 and milk is now contributing only 22% of the Sr^{90} in the diet; without it present, the strontium units in the diet are five times higher (34 up to 176 S.U.). Note that a high level of Sr^{90} in a food of which normally little is consumed can contribute a significant amount of Sr^{90}, i.e., 10 g., or one leaf, of lettuce is contributing about as much Sr^{90} to this diet as 200 g. of flour or a pint of milk.

It is apparent that reporting Sr^{90} levels as either the $\mu\mu c.$ present per kilogram or as the strontium units present has disadvantages and that the only absolute way to evaluate a diet is to know both the $\mu\mu c.$ of Sr^{90} and the calcium level present. In general, since most foods contain less than 1 g. of calcium per kilogram (milk and most milk products are the notable exceptions), values reported as $\mu\mu c.$ of Sr^{90} are numerically lower than values reported as strontium units. However, there is danger in this for, without recognizing the situation with respect to calcium, the tendency is to suspect and eliminate the foods from the diet with the highest $\mu\mu c.$ values, and this is exactly what the public has done in some areas with respect to milk. In so doing, of course, the calcium level in the diet is reduced and the bone deposition level of Sr^{90} goes up.

TABLE 3

Calculations of dietary level of Strontium[90] [a]

Food	Daily amount consumed (kg.)[b]	Calories in portion	Mg. calcium per kg.	Mg. calcium in portion	CASE I: S.U. the same — $\mu\mu$c. Sr^{90} per kg.	CASE I: S.U. the same — $\mu\mu$c. Sr^{90} in portion	CASE I: S.U. the same — S.U. in food	CASE II: $\mu\mu$c. the same — $\mu\mu$c. Sr^{90} per kg.	CASE II: $\mu\mu$c. the same — $\mu\mu$c. Sr^{90} in portion	CASE II: $\mu\mu$c. the same — S.U. in food	CASE III: More typical values — $\mu\mu$c. Sr^{90} per kg.	CASE III: More typical values — $\mu\mu$c. Sr^{90} in portion	CASE III: More typical values — S.U. in food
Milk	.50	340	1,180	590	11.8	5.90	10	10	5.0	8	10.6	5.3	9
Meat, beef	.35	1,120	100	35	1.0	.35	10	10	3.5	100	1.8	.6	18
Flour, whole wheat	.20	728	160	32	1.6	.32	10	10	2.0	63	25.6	5.1	160
Potatoes	.15	125	110	17	1.1	.17	10	10	1.5	88	3.3	.5	30
Corn, sweet	.03	28	90	3	.9	.03	10	10	.3	100	18.0	.5	200
Tomatoes	.04	8	110	4	1.1	.04	10	10	.4	100	2.2	.1	20
Peas	.02	20	220	4	2.2	.04	10	10	.2	50	220.0	4.4	1,000
Lettuce	.01	2	220	2	2.2	.02	10	10	.1	50	550.0	5.5	2,500
Apples	.05	29	60	3	.6	.03	10	10	.5	166	30.0	1.5	500
Peaches	.05	28	80	5	.8	.05	10	10	.6	120	4.8	.3	60
Totals in diet[c]:													
With milk	1.41	2,428	.....	695		6.95			14.1		23.8		
				.695 g.		$\frac{6.95}{.695}$ = 10 S.U.			$\frac{14.1}{.695}$ = 20 S.U.		$\frac{23.8}{.695}$ = 34 S.U.		
Without milk	.91	2,088	.....	105		1.05			9.1		18.5		
				.105 g.		$\frac{1.05}{.105}$ = 10 S.U.			$\frac{9.1}{.105}$ = 87 S.U.		$\frac{18.5}{.105}$ =176 S.U.		

[a] This diet is calculated so that 85% of the calcium in it comes from milk, 5% from other animal sources (meat, fish, eggs, etc.), and 10% from plant-food sources. This is about the average dietary calcium source for people in the United States (17). The diet includes 1 pt. of milk per day (or milk product equivalent), which is also average in the U. S. Other foods as fats, sugars, etc., also would be in a complete diet, but these do not contain significant amounts of calcium or Sr^{90}. Values are taken from (15) for calcium and caloric levels. It should be noted that the recommended daily calcium intake is 0.8 g. for adults (15).

[b] A kilogram (kg.) is 1,000 g. or 2.2 lb., and is about the same weight as a liter or quart of milk (1 qt. is 0.946 liter, 1,033 g. of milk per liter).

[c] The total micromicrocuries ($\mu\mu$c.) of Sr^{90}, divided by the total grams of calcium, gives the strontium units (S.U.) in the total diet. This level times one-fourth to one-half gives the bone deposition level of Sr^{90} in strontium units that can result from consuming this diet. This level will deposit in the bones of children forming new bone; in adults, where bone was previously laid down, the rate of Sr^{90} moving into the bone is smaller. Kulp *et al.* (16) estimate that 1% per year of the calcium in the intercrystalline lattice of bone is exchanged with new dietary calcium (and Sr^{90}). The exchange rate is higher in spongy bone so, taking all factors into consideration, they estimate that 3.8% per year of the total bone calcium in the body is replaced with dietary calcium and Sr^{90}, at the level it exists in the current diet. Since the adult human body contains about 1,000 g. of calcium, a person on a diet containing 40 S.U. would deposit in a year $0.25 \times 40 \times 0.038 \times 1{,}000$, or 380 $\mu\mu$c. of Sr^{90}, giving an over-all level of 0.38 S.U. in the bones.

Thus, the author feels that for determining permissible Sr^{90} levels in the diet a system based on the strontium unit, not the absolute $\mu\mu c.$ of Sr^{90} in the diet, is the procedure that should be given the major consideration. Yet, it is recognized that there are some advantages in reporting data on individual foods as the absolute amount of Sr^{90} instead of strontium units present. Assessing the relative importance of both systems needs to be done as far as public understanding is concerned. In any event, the calcium content of individual foods can not be ignored, for if it is, and only absolute $\mu\mu c.$ levels are reported, the higher calcium-containing foods like milk will appear high in Sr^{90} relative to other foods.

(d) Metabolism of Sr^{90} in relation to calcium. Various studies have indicated that whereas the discrimination against Sr^{90} is chiely dependent on the calcium level present, other minerals and substances in the diet also may be factors. The effects of other minerals and the factors controlling calcium metabolism within the body are areas about which little is known, and still less is known about Sr^{90} metabolism. For example, the intercrystalline exchange of calcium with new calcium within the bone has been estimated at about 1% per year (16). The exchange rate with spongy bone is estimated to be higher, so that about 3.8% of the bone calcium in an adult is exchanged per year. These values need to be determined more accurately. Does Sr^{90} have the same rate, or is it smaller or larger? If significantly greater than calcium, for example, Sr^{90} might be removed from the bone at a rate greater than calcium. Recent work suggests this may be true (25); in fact, Sr^{90} may not enter the crystalline structure at all (27). This raises the possibility of significantly lowering an accumulated high bone level of Sr^{90} by increasing the Sr^{90} exchange rate on a high calcium diet (possibly mediated by hormonal or vitamin D inclusion).

Fluctuations in the dietary intake of calcium also raise the question of whether this intake should be steady. For example, if milk contains 10 S.U. and the P/M ratio is ten, a person consuming 1 pt. of milk per day in a diet containing 19 S.U. will accumulate a level of about 5 S.U. in the new bone being laid down; whereas, a person consuming no milk on the same diet will have 100 S.U., leading to a bone level of 25 S.U. Does a person consuming 1 qt. of milk every other day accumulate in his new bones 3 S.U. one day and 25 S.U. the next, for an average of 14 S.U., or does he accumulate a level of 5 S.U., also? The questions to be answered in this area are many, and require resolution before absolute dietary recommendations for minimum bone levels of Sr^{90} can be ascertained. The safest course is to keep the calcium level in the diet high at all times relative to the Sr^{90} present.

(e) Removal of Sr^{90} from milk. It is apparent by this time that as the P/M ratio increases the pertinence of removing Sr^{90} from milk becomes less important, since it contributes a smaller amount of Sr^{90} to the diet. The best course would be to remove Sr^{90} from foods of plant origin; however, they do not lend themselves to this treatment like milk, since milk exists in a fluid state. Thus, studies are progressing at several locations to determine methods to remove Sr^{90} from milk.

It is highly unlikely that any method can be devised to remove 100% of

the Sr^{90} from milk. It is also unlikely that over 50% of the Sr^{90} could be removed from milk and still be economically feasible. The maintenance of the calcium level in the diet is so important that for removal processes to be effective they must not lower the calcium level, or increase the price of milk which would discourage consumption, unless metabolizable calcium were added to the diet from other sources.

The argument has been advanced that in the event of an atomic holocaust, as a result of nuclear warfare, it would be desirable to have a removal process available. Such a process might be of limited use on a short-term basis while most of the increased fallout was on the surface of plants, where it could be removed by washing. However, it should be noted that the addition to milk of an equal amount of calcium is just as effective as removing 50% of the Sr^{90}. The use of an increased calcium level in the diet in the period following an atomic attack may be more pertinent than trying to remove the Sr^{90} from milk.

Thus, the evidence suggests that it is more pertinent now to determine the significance of the role of milk in our diet by assessing the P/M ratio, discrimination factor, etc., than to develop means to remove Sr^{90} from milk. It is apparent, however, that local conditions might alter these considerations. For example, in an area where a low P/M ratio exists because either milk or the plant foods consumed are shipped in from other areas, then conceivably, it could be advantageous to remove the Sr^{90} from milk if it did not cause decreased consumption. However, the other situation is more likely to occur where plant foods grown in higher fallout areas (i.e., wheat and other cereals grown on the plains of the Northern Hemisphere) are shipped into areas where the Sr^{90} level in milk is low so the P/M ratio is high. In this case, it may be more pertinent to raise milk consumption, to decrease the Sr^{90} level depositing in the bones.

It is apparent that these considerations show the importance of determining the Sr^{90} content of other foods in the diet, notably those of plant origin. Since plant foods vary so widely in Sr^{90} content, compared to milk which is pooled from many cows, farms, and areas in a milk-shed, many more analyses are needed on plant foods to accurately assess their contribution of Sr^{90} to the diet. Thus, the answer to the question as to whether methods should be devised to remove Sr^{90} from milk is in the negative if the P/M ratio is high and the Sr^{90} levels in plant foods are ignored. The answer is in the affirmative if the P/M ratio is low or if we desire to remove all of the Sr^{90} from our food supply, and then we must either remove plant foods from our diet or remove the Sr^{90} from them, also.

(5) *Public relations.* The popular article also appearing in this issue (18) discusses the public relations aspects of radioactive fallout in general and milk in the Sr^{90} problem. Since the evidence indicates that it has been the high calcium level in milk that protects the American public from much higher levels of Sr^{90} accumulating in their bones, it is important for the public to recognize the role of milk in the diet.

Thus, public relations is listed as a research area needing more attention, since the public has been led to believe that milk is the principal source of radioactivity in their diets. This concept is being fixed firmly in the minds of our

children, since elementary textbooks are now beginning to show the primary route of Sr^{90} to man through the cow; and, in the minds of adults every time the frequent articles appear in the popular press on the current levels in milk, on the research programs on removing Sr^{90} from milk, etc., without mention of the role milk has been taking in supplying the calcium in our diets necessary to reduce Sr^{90} deposition. The author feels that the situation has gone too far when the information people have been receiving has led them to question their consumption of milk and in some instances actually to reduce or eliminate milk from their diet. Recent evidence would suggest that such publicity has been working to the detriment of the health of the American public. In any event, it is apparent that much is still to be learned about Sr^{90} in our diets, and premature information released without proper interpretation can be harmful.

It is hoped that the considerations raised in this article will not be interpreted as completely vindicating milk in the Sr^{90} problem. The author does feel that milk has received undue criticism, that the facts now accumulating show to be unwarranted. On the other hand, enough facts are not yet available to completely define the role of milk in the diet and much further research in this direction is certainly needed.

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THE RAPID DETERMINATION OF MINERALS AND IONS IN MILK. II. DETERMINATION OF CHLORIDE

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SUMMARY

A titrimetric and potentiometric method are presented and evaluated for the determination of chloride in milk and milk products. The titrimetric procedure involving direct titration of the chloride with mercuric nitrate in a nitric acid solution can not be applied satisfactorily to the determination of chloride in low concentrations (that is, below 4 to 10 mg. of chloride per 100 ml. of solution). However, it is applicable to determination in milk and many milk products. Precipitation of proteins with nitric acid is preferred to ashing for obtaining the solution for titration. The potentiometric method for chloride, involving the determination of the potential between a silver–silver chloride electrode and a palladium–mercury calomel reference electrode, when immersed in the test solution, is accurate and very rapid. An accuracy of +5 or +2% is obtainable, depending upon the sensitivity of the potentiometer. Care must be taken to keep the temperature of the solution constant and the silver–silver chloride has to be protected from contamination. Substances capable of dissolving the silver chloride coating, such as free amino acids, must be inactivated by the addition of copper sulfate to the sample solution.

As pointed out in a previous publication (8) on the analysis of sodium, potassium, magnesium, and calcium in milk, the rapid and accurate determination of the composition of the electrolytes in milk is very important in the present-day research in the dairy field. The present paper deals with the chloride analysis in milk. Until now, chloride has been difficult to determine accurately in small samples.

Titrimetric methods, as discussed by Schales and Schales (6), have been widely used, but in milk the titration end point is difficult to recognize because of the protein interactions. After elimination of the proteins, the chloride concentration is often too low to allow accurate titration. Concentration of the sample introduces new errors. Ashing of the samples is tedious and losses of chloride occur. The Votocek (7) titration with mercuric nitrate was the most satisfactory method and is described. This method has been used in our laboratories for more than 10 yr. (unpublished), but especially in dialysis experiments this method was not sensitive enough. The potentiometric chloride analysis described by Chanin (4) and Johns (5), applied to blood serum analysis, proved to be very satisfactory for chloride analysis in milk, down to concentrations of chloride of 1 p.p.m. Dilution of 1% of fluid milk gave excellent results and errors could be kept on the $\pm$ 2% level. In the present paper we shall describe these two methods. The titrimetric procedure can be used with good results for occasional chloride determinations if the concentrations are high enough. The potentiometric analysis is time-saving and very accurate, especially for routine work in series.

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METHODS

(1) The titrimetric Votocek (7) chloride analysis, reagents:

0.01 *N* mercuric nitrate Hg $(NO_3)_2$, solution in 1% nitric acid.
10% solution of nitroprusside of sodium.
Concentrated analytical-grade nitric acid diluted to twice the volume with distilled water.
0.01 *N* HCl as standard solution for Cl titration, to control the mercuric nitrate solution.

Analytical procedure. To 30 ml. of milk or reconstituted dry milk, 10 ml. of nitric acid 1 : 1 are added. The sample is mixed thoroughly, the volume is made up to 50 ml. and heated for 3 to 5 min. in a boiling water bath. After cooling to 20° C., the precipitate is filtered off and an aliquot part, containing 2 to 5 mg. of Cl, of the transparent solution is taken. The volume of this sample should not exceed 50 ml. For the titration, 10 ml. of nitric acid and ten drops of the nitroprusside indicator are added. No opalescence or precipitation should occur. Titration with the 0.01 *N* mercuric nitrate solution follows immediately until a whitish opalescence persists for at least 10 sec. The correct volume of the mercuric nitrate is calculated by subtracting the reagent blank and multiplying by the correction factor established by titration of the 0.01 *N* HCl. Opalescent or turbid solutions can not be titrated. The acid filtrate may then be centrifuged or hydrolyzed on a boiling water bath for a further 15 to 30 min. to get a clear solution.

(2) *The potentiometric chloride analysis.*

The potentiometric method for chloride determination, as described by Chanin (4) and Johns (5), was adopted because of the ease of sample preparation and the very high sensitivity for concentrations as low as 1 to 10 p.p.m. This method is particularly suitable for analysis in series.

Apparatus and reagents

pH Meter Beckman Model GS.
No. 1264 Beckman silver–silver chloride electrode.
No. 1170 Beckman palladium–mercury calomel reference electrode.
1.5 v. dry cell for the rejuvenation of the silver electrode.
1 *N* H_2SO_4.
1% solution of $CuSO_4 \cdot 5\ H_2O$, equivalent to 2.5 mg. Cu per ml.
5% solution of KCl.

Analytical procedure. The silver electrode has to be cleaned and rejuvenated following the instructions of Beckman Instruments, Inc. (2, 3). To clean the silver rod of the silver–silver chloride electrode, we used very fine powdered quartz and analytical grade calcium carbonate mixed with "Vel" detergent on a clean wet cloth. By very gentle rubbing with quartz powder, most of the hardened silver chloride coating is removed. The chloride is then polished with $CaCO_3$ powder. After rinsing with distilled water, the silver chloride coating

is carried out in a 5% KCl solution just acidified with a few drops of 0.1 N H_2SO_4, following the instructions of Beckman (2, 3). The rejuvenated silver–silver chloride electrode can be stored without damage for several months in the acidified 5% KCl solution.

The sample to be analyzed is diluted to an appropriate chloride concentration, preferably between 10 and 100 p.p.m. A certain amount of 1 N H_2SO_4 is added to obtain a final concentration of 0.1 N H_2SO_4 in the solution to be measured. Copper sulfate is added to obtain a final concentration of 10 p.p.m. of Cu in the diluted sample. The copper as a chelating agent protects the silver chloride coating of the electrode. This coating is easily dissolved by free amino acids or other organic compounds if present even in very low concentrations, as it occurs in fresh milk.

By means of the two electrodes connected to the Beckman pH Meter Model GS, the cell potentials are read as mv., using the sensitivity "A" if an accuracy of not better than $\pm$ 5% is needed. If accuracy of $\pm$ 2% seems desirable, the sensitivity "B" should be used and the cell potentials read by means of the helipot scale. In this case, it is necessary to take the mean value of three to five measurements of the same sample to obtain correct readings. It is also very important to keep all solutions at the same temperature, preferably at room temperature, which should be held constant during the whole operation. We refer to the instruction manual of Beckman (1) for all details on the operation

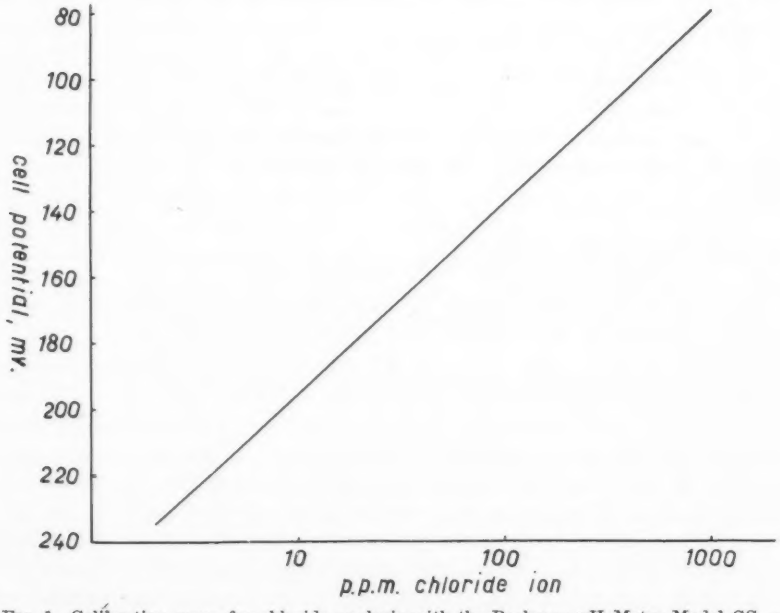

FIG. 1. Calibration curve for chloride analysis with the Beckman pH Meter Model GS, set on sensitivity "A."

of the pH Meter Model GS with the sensitivities "A" and "B." Typical calibration curves are shown in Figures 1 and 2. The exact position of the calibration curve depends on the temperature and for this reason every time an analysis is run a standard chloride solution has to be measured to fix the exact position of the standard curve, which is displaced strictly parallel by very slight temperature differences.

FIG. 2. Calibration curve for chloride analysis with the Beckman pH Meter Model GS, set on sensitivity "B."

RESULTS AND DISCUSSION

In Table 1 some mean values of chloride determinations are shown, using different procedures to prepare the samples and applying different analytical methods to the same milk samples. It becomes evident that ashing is not to be recommended, because of the losses of chloride at temperatures over 400° C. The titration method after the precipitation procedure with nitric acid yields much better results, but potentiometric analysis seems to be the most reliable. This is demonstrated in Table 2 by recovery experiments in a wide concentration range for chloride. With the Beckman Model GS pH Meter set at sensitivity "A," a maximum deviation of two single determinations of ± 10% and a mean deviation of ± 4% have been found. If the pH Meter is set at the sensitivity "B," the mean deviation is depressed to ± 2%, because of the more accurate readings on the pH Meter and even without special equipment for better temperature control. If greater accuracy is needed, a device for constant temperature control with variations of not more than ± 0.1° C. is necessary. In this case, accurate sampling

TABLE 1

Comparison of Cl content, using different procedures in milk and modified milk products

Samples analyzed	No. of samples	Total Cl titrated after Ashing	Precipitation with HNO_3	By potentiometric determination	Dialyzable[d] Cl potentiometric
		(% of total solids)			
Modified dried milk (baby food)	7	0.47	0.60		
Modified dried milk (experimental)	2	0.12	0.20		
Full cream powdered milk[a]	5		0.85	1.0	0.95
Acidified modified full cream dried milk[b]	3		0.45	0.52	
Half skimmed acidified dried milk[c]	3		0.93	0.99	
Skimmilk 9.5% total solids	9			1.18	1.14
Rennet whey 6.4% total solids	2		1.8	1.8	
	1			2.0	2.1

[a] Nido (Nestlé).
[b] Pélargon (Nestlé).
[c] Eledon (Nestlé).
[d] All dialysis experiments refer to equilibrium dialysis of not more than 5% water in the dialysis bag, relative to the total volume of milk.

becomes the troublesome problem for chloride analysis. Some difficulties met with the silver–silver chloride electrodes, because of the attack on the silver chloride coating, could be overcome by adding copper sulfate to the diluted solutions. Concentrations of 5 to 50 p.p.m. of copper have been shown to be effective without impairing the potentiometric measurements. Free amino acids have been found to be particularly active in dissolving the silver chloride coating.

TABLE 2

Wide concentration range recovery experiments of the potentiometric chloride determination with sensitivity "A"

Milk samples	Concentration of milk sample solids in 0.1 N H_2SO_4	Cl found	Cl added	Total Cl Found	Total Cl Expected	Deviation
	(%)		*(p.p.m.)*			*(%)*
Fresh skimmilk	0.045	5.8	5.0	11.0	10.8	+ 2
	0.09	11.0	10.0	23.0	21.0	+10
	0.9	106	100	210	206	+ 2
Full cream powdered milk[a]	0.05	5.2	5.0	10.4	10.2	+ 2
	0.10	10.4	10.0	19.0	20.4	− 7
	1.5	153	150	290	303	− 4
Acidified modified full cream dried milk[b]	0.05	4.9	5.0	10.3	9.9	+ 4
	0.10	9.8	10.0	20.6	19.8	+ 4
	1.0	105	100	200	205	− 2
					Maximum	±10
					Mean	± 4

[a] Nido (Nestlé).
[b] Pélargon (Nestlé).

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RELATIVE CLEANABILITY OF VARIOUS STAINLESS STEEL FINISHES AFTER SOILING WITH INOCULATED MILK SOLIDS[1]

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SUMMARY

A semiautomatic spray-washing device, which provided controlled rinsing and washing without brushing, was used to determine the relative cleanability of Type 302 stainless steel panels having a No. 2B, 3, 4, and 7 finish after soiling with skimmilk inoculated with *Bacillus globigii* spores.

Using the Direct Surface Agar Plate test at the 1 and 5% level, no significant difference was observed among these finishes after the test areas were rinsed (T-2), rinsed and washed with alkaline detergent (T-3), and rinsed, washed, and sanitized (T-4). This study indicates that the less highly polished finishes can be cleaned bacteriologically to the same degree as the highly polished No. 7 surface when the same cleaning cycle is used.

No significant difference in bacterial cleanability was observed among finishes at the 5% level with the Standard Swab Contact Test after T-3 and after T-4.

With the Direct Agar Contact Plate, a significant difference was observed among No. 2B, 3, 4, and 7 finishes after T-2, T-3, and T-4. The recovery of bacterial cells by this test was less than that obtained in the DSAP and Swab Contact Tests and indicates the unreliability of this test.

In all trials, the bacteria counts decreased markedly as the washing procedure was changed from a minimum rinse to a complete cycle of rinse-wash and sanitize.

The relationship between the finish of Type 302 stainless steel and the ease with which bacteria may be removed from the surface has been of interest to public health officials, sanitarians, and dairy equipment manufacturers for some time. Numerous studies have been made on the cleanability of Type 302 steel having a No. 4 finish, but little information is available on the comparative cleanability of this steel type having a No. 2B, 3, 4, or 7 finish.

This study was undertaken to determine the relative cleanability of Type 302 stainless steel panels having a No. 2B, 3, 4, and 7 finish when these surfaces are compared under identical conditions of soiling and spray cleaning and tested using the Direct Surface Agar Plate procedure (2), which detects the viable bacteria actually remaining on the surface, in contrast to other procedures which detect the bacteria removed. In this study, a deliberate attempt was made to minimize the cleaning procedures so some bacteria would remain on all surfaces after rinsing, rinsing and washing, and rinsing, washing, and sanitizing. The term relative cleanability is used because the object of the study was to compare the relative numbers of bacteria remaining on each finish after each cleaning treatment.

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Hays *et al.* (4) studied the removal of air-dried films of whole milk, contaminated with *Escherichia coli*, from 18-8 stainless steel panels having 2B, 7 mill, 80, 100, and 120 grit surfaces after scrubbing for 15 sec. with an alkaline cleaner at room temperature; with the No. 7 mill finish, 100% removal was noted. Somewhat similar results were obtained after washing with an anionic, nonionic, or acid cleaner at room temperature.

Ridenour *et al.* (7), using a saline suspension of *Micrococcus aureus* as a soiling material, obtained 49% removal, based on radioactive tracer methods, after rinsing stainless steel with water at 60° F. for 1 min.; 97% of the total removal was observed using a detergent wash at 160° F. for 3.5 min. in a commercial jet-spray dishwasher. The specific finish of the steel surface was not identified. In a milk soil, these workers removed more than 99% of the total soil applied.

Masurovsky *et al.* (6) used radioactive *E. coli* and *Micrococcus pyogenes* var. *aureus* cells in homogenized whole milk as a test soil. Cleaning was accomplished by mechanical brushing in alkaline detergent solution at 120° F. for 1.125 min., followed by rinsing for a similar time. On the basis of Duncan's Multiple Range Test (3), which considers basically the extreme values of the data, no significant difference was observed between stainless steels having a No. 7, 4, or 3 finish. Under the same test conditions, a No. 2B finish was significantly different from the No. 3, 4, and 7 finish. In another series of experiments with no brushing these workers found no significant difference between No. 4 and 7 finishes when *M. pyogenes* var. *aureus* suspension in 0.85% saline was used as the test soil; no significant difference was observed between No. 3 and 4 finishes when these two finishes were compared. Under the same test conditions, the cleanability of the No. 2B finish was significantly different than that obtained with the No. 3, 4, and 7 finishes.

MATERIALS AND METHODS

Selection of panels. To secure samples representative of the steel industry's production, 8- by 8-in. panels of Type 302 stainless steel having 2B (bright cold-rolled), 3 (80-100 grit), 4 (120-150 grit), and 7 (325 grit plus buffing) finishes were obtained from six of the largest steel companies representing most of the stainless steel production. Where possible, 5-mill samples of each finish were obtained. In all, 30 panels of each finish except 7 were received; only 25 panels of this finish were received. The roughness of all panels was determined, using a Brush Surface Analyzer. The panels of each finish were arranged in order of roughness and 12 panels of each finish were randomly selected to provide the actual specimens used in this study.

An invisible soil on the new panels, possibly from the adhesive used on the protective paper covering or oil film, made it impossible to spread the soil evenly. To remove this film the panels were brushed with tetrachlorethane, washed with alkaline detergent at twice the minimum recommended level for very hard water, brushed with a recommended organic acid cleaner at twice the recommended concentration, and rinsed in distilled water.[2] This treatment was used only initially to remove the invisible soil. Following this preliminary cleaning, the

panels were brush-cleaned after each trial with a common chlorinated alkaline dairy detergent at twice the suggested minimum level for very hard water. Brush cleaning between trials was necessary to remove a stain left by the agar and swab solution. All plates were brushed with an organic acid cleaner after each experimental trial. Since the objective of this study was to investigate the cleanability of the stainless steel with different finishes, a thorough cleaning was undertaken between each trial to eliminate soil build-up.

Soil suspension and soiling. Skimmilk was selected as the soiling medium, since it appeared to adhere more tenaciously to the surface than whole milk and represents actual field soiling conditions more nearly than do other soils, such as saline solutions or synthetic charcoal egg mixtures.

Approximately 10 g. of a concentrated paste of *Bacillus globigii* spores were suspended in 100 ml. of sterile distilled water, filtered to remove debris, washed and centrifuged five times to clean the spores, heat-shocked at 80° C. for 10 min., resuspended to a total volume of 400 ml., and stored at 5° C. Immediately before use, 5 ml. of the stock suspension was heat-shocked again and diluted in sterile skimmilk to obtain a spore level of about 500,000 per milliliter.

To minimize complications due to air and dust contamination, the steel plates were flamed with alcohol before each soil application. One-tenth milliliter of the spore-skimmilk suspension was carefully pipetted onto and spread evenly by means of a sterile rubber spatula over the 4 sq. in. test area. The test area was well-defined by means of a rubber mask placed on the plate. Standard plate counts were made to determine the initial level of inoculum. Initial counts on the test areas ranged from 34,000 to 73,000 per 4 sq. in.; for purposes of analysis all results were corrected to a base level of 50,000 cells. The spore-skimmilk film was fixed by drying for 20 min. at 37° C. To eliminate area variables and to randomize the influence of the "lay of the grit lines," the steel panels were rotated 90° after each trial; in this way, it was possible to test four different areas with each of the three tests used. To maintain constant washing conditions in all trials, it was necessary to locate the test area on the outer edges of the test panel.

Cleaning device and procedures. An automatic washing device (Figure 1) was used to eliminate the variation associated with any hand-washing procedure. It consisted of a power-driven feed rack which carried the steel panels under a series of four spray arms. Each panel was placed on the rack at the top position and was carried down the rack under the spray arms, which could be controlled individually. The arms were 8 in. long and were located 5 in. above the surface of the test panels. The evenly dispersed, constant-pressure spray was created by a double row of staggered holes $\frac{1}{16}$ of an inch in diameter and $\frac{1}{4}$ of an inch apart. The arms were 12 in. apart. The hardness of the water used in this study was approximately 80 p.p.m.

The first spray arm provided sufficient water to merely wet the panel; the flow rate was 2 liters per minute evenly distributed over the length of the arm.

[2] Tetrachlorethane is poisonous and should not be used in routine practice; since the initiation of this study, a special commercial cleaner is available which can be obtained from various commercial detergent supply houses.

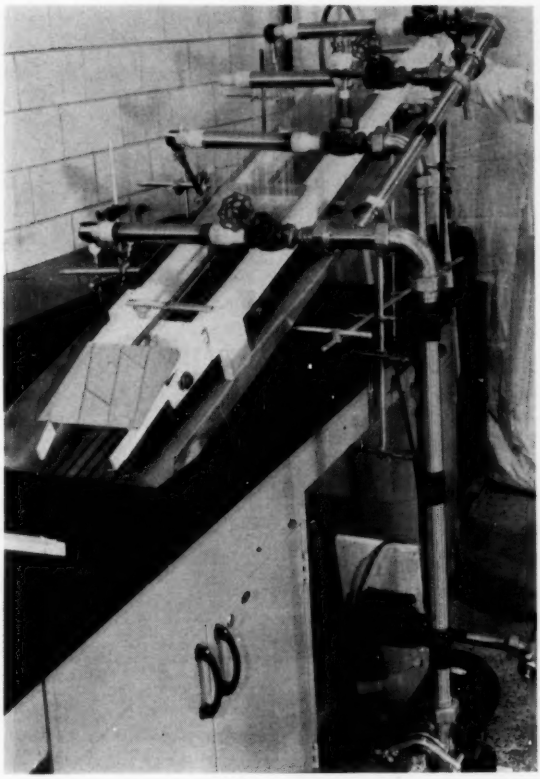

FIG. 1.

Each 4 sq. in. test area was exposed for 2 sec. to the actual spray; this provided about 4 ml. of prerinse water at 45° C. per square inch. This prerinse can be characterized as a running-drip.

A second spray arm similar in design to the above provided a mild spray designed to simulate a fair rinse. The same water supply was utilized, but the flow rate was four times as great. The total time that each panel was wet with flowing water in the prerinse and rinse phase was 18 sec. The rinsing conditions were held to a minimum to prevent removal of all the bacteria.

The third spray arm provided the detergent wash. The hardness of the wash water was 14 p.p.m. A proprietary chlorinated alkali was used at a level of 1 oz. per 5 gal. of water, as recommended for soft water. The water temperature was 70–74° C. The flow rate was 7.1 liters per minute over the entire spray arm; this provided approximately 15 ml. of wash water per square inch of test area. In this operation, the entire panel was wet with detergent solution for 12 sec., but the test area received actual spray treatment for only the standard 2-sec. period.

The fourth spray arm provided a final rinse to flush away the detergent solution. The same water was used as in the initial rinse. The flow rate was 2.4 liters per minute; this provided 5 ml. of rinse water per square inch. The total time the soiled area was exposed to the actual spray and flushing action was 5 sec. The panels were drained to remove excess water prior to sanitization. Drainage time ranged from 5 to 20 sec. Minimum washing conditions were employed to avoid flushing too many organisms from the surface, making a statistical analysis impossible.

Sanitization was accomplished by immersing each panel for 1 min. in 100 p.p.m. chlorine solution. Two 10-sec. rinses in fresh water served to remove the sanitizer from the surface. Drying the panel in a dust-free chamber at 35° C. for 20 min. constituted the final step prior to testing, regardless of the cleaning treatment employed.

Since cleaning operation, as it is usually carried out in practice, is broken down into three major cycles; rinsing, washing, and sanitizing, the effect of each of these treatments on the cleanability of the various surfaces was investigated. The rinse operation (T2) consisted of the prerinse and rinse from spray arms No. 1 and No. 2, respectively. By removing the plates after this treatment, it was possible to study the efficiency of this operation per se. Following this treatment, the entire soiled area remained faintly visible on all surfaces upon drying. By removing the panel after passing under the prerinse, rinse, and detergent-rinse spray nozzles, it was possible to study the effect of a rinse followed by a detergent wash (T3) on the cleanability of the surface. In (T4) the plates were rinsed, washed with detergent, and sanitized. This sequence represented a cleaning operation approximating spray washing.

Direct Surface Agar Plate. The Direct Surface Agar Plating (DSAP) technique, as described by Angelotti and Foter (2), was used to determine the bacteria remaining on each surface after the various cleaning treatments. This test differs considerably from the two other tests, in that it indicates the number of viable bacteria remaining on the surface under investigation. The 4 sq. in. test area examined with this procedure was obtained by means of a circle $2^{3}/_{16}$ in. in diameter. To avoid marking the surface of the plate with wax pencil, rubber jar rings were placed into a previously spotted position on the mask (Figure 2). This ring provided a dam to retain the molten agar on the test area until it hardened. Sterilizing these jar rings eliminated contamination from this source. After aseptically placing the agar-retaining ring into position, the surface was flooded wth 10 ml. of plate count agar at 48–52° C. A sterile Petri dish cover containing moistened sterile filter paper was placed over the test area, to aid in maintaining the desired humidity and to eliminate atmospheric contamination. Each panel was placed in a rack and the entire group of panels was incubated over water in a chamber which provided 93% R.H. at 35 ± 1° C. After 16–18 hr. of incubation, the agar overlay was flooded with 0.5% aqueous solution of 2,3,5-triphenyl 2H-tetrazolium chloride. The colonies became red after this treatment and simplified the counting procedure.

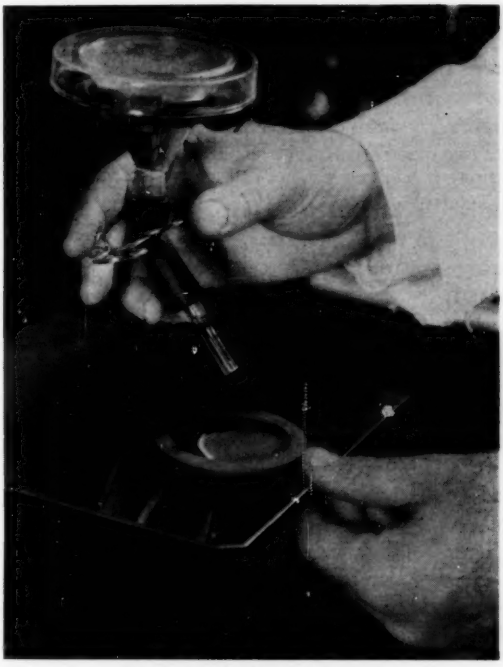

FIG. 2. DSAP technique.

In this, as well as in all other testing procedures, three panels of each finish were used to give three replications of each test under each cleaning treatment. Fifteen complete experiments were carried out; this provided 45 replications of each test procedure for each cleaning treatment on each finish examined.

Swab Contact Method. In using this test, the procedure described in *Standard Methods for the Examination of Dairy Products* (1) was followed, except that 4 rather than 40 sq. in. were tested. The total area examined comprised a 4 sq. in. area (2 by 2 in.). The test area was clearly defined by the film of skimmilk solids which remained after rinsing, but it was not visible after detergent washing. To delineate the limits of the test area, a sterile template was placed on the plate.

The effective contact length of the cotton swab per se was 0.5 in. The 2 by 2 in. area was completely swabbed with four passes of the swab. Each 0.5- by 2-in. band was swabbed by passing the moistened swab over the area three times while continually rotating the swab stick. After swabbing two bands (2 sq. in.), the swab was whip-rinsed in 8 ml. of phosphate buffer in 3-in. screw-cap vials and pressed out prior to swabbing the remaining half of the area. The swab was removed from the stick by breaking it in buffer solution. Plate count agar was used to prepare duplicate 1.0- and 0.1-ml. plates. Counts were made after 48 hr. of incubation at 35 ± 1° C. The number of colonies per 4 sq. in. area was calculated from these data.

Direct Agar Contact Plate. A Direct Agar Contact plate was also used to determine the number of bacteria removed from the various surfaces under the test conditions. The hypodermic syringe technique of Litsky (5) was modified to provide a flat sterile agar surface equivalent to 4 sq. in. of area. The exterior barrel of the modified syringe consisted of an 8-in. piece of glass tubing having an I.D. of 2½ in. The interior plunger consisted of an 8-in. section of glass tubing having an O.D. of 2⅛ in. and an I.D. of $1\frac{15}{16}$ in. A rubber stopper was fabricated to fit into the end of the interior tube to make the plunger. Using this syringe, it was possible to make a contact impression of the entire 4 sq. in. test area.

The glass syringe was assembled, wrapped in paper, and sterilized by autoclaving. Immediately before use the syringe was unwrapped, clamped around the barrel in a vertical position with the plunger drawn back, and filled with tempered sterile plate count agar. A sterile Petri plate was used to cover the open end of the plunger while the agar hardened and while the unit was not in use. The area designated for the direct agar contact test was located by means of the mask previously described. Two contact impressions each of 5-sec. duration were made on each site; the syringe was rotated 180° between impressions to eliminate dead spots due to entrapped air. After making the contact, the plunger was adjusted to expel ⅜ of an inch of solidified agar; this was smoothly sliced from the agar column, using a sharp sterile knife. The agar slab was allowed to slide into a sterile Petri dish with the contact surface up. Bacterial colonies on the contact agar slabs were counted after incubation at 35 ± 1° C. for 48 hr. The number of colonies per 4 sq. in. of test area was determined.

RESULTS AND DISCUSSION

Direct Surface Agar Plate. The data given in Tables 1, 2, and 3 for Treatments T-2, T-3, and T-4 represent the average obtained from three replications of each test, using 12 steel panels of each finish. The initial level of the inoculum applied to each test area was determined, using the Standard Plate Count (SPC) procedure. In view of the daily variation observed in the initial level of inoculum (34,000 to 73,000), the counts obtained were corrected to a base level of 50,000 for statistical analysis. In the statistical analysis the corrected actual individual counts were used rather than the average value. The analysis of variance design was set up to answer the question: "Is there a difference in cleanability of Type 302 stainless steel panels having a No. 2B, 3, 4, and 7 finish when these surfaces are compared under comparable conditions of soiling, cleaning, and testing?" The change in bacterial number due to the cleaning technique was used to indicate the degree of cleanliness of the test surface. A summary of the analysis of variances findings is given in Table 4.

The results of the statistical analysis indicate no difference at the 5 or 1% significance level in the cleanability of a No. 2B, 3, 4, or 7 finish after Treatments T-2 T-3, and T-4, when the Direct Surface Agar Plate procedure is used. It is important to note that this test is more critical than either the Swab or Agar Contact Test, since it is not dependent upon the removal of the bacerial cell prior to detection but detects the cell in situ. The fact that the plating and incu-

TABLE 1

Bacterial counts per 4 square inch of surface after various cleaning treatments using the direct surface agar plate test

Expt. No.	SPC[a]	Finish No. 2B Cleaning treatment				Finish No. 3 Cleaning treatment				Finish No. 4 Cleaning treatment				Finish No. 7 Cleaning treatment			
		T-1[b]	T-2[c]	T-3[c]	T-4[c]	T-1	T-2	T-3	T-4	T-1	T-2	T-3	T-4	T-1	T-2	T-3	T-4
	(× 1,000)	*(× 1,000)*				*(× 1,000)*				*(× 1,000)*				*(× 1,000)*			
1	60	63	255[d]	33[d]	46[d]	67[d]	195[d]	32[d]	19[d]	61[d]	214[d]	77[d]	19[d]	59[d]	154[d]	75[d]	35[d]
2	43	62	204	34	14	65	125	20	7	44	98	26	31	53	101	20	6
3	68	78	254	30	7	64	179	24	5	81	224	8	15	79	211	27	2
4	58	66	123	14	17	57	56	23	5	65	28	18	1	51	28	13	3
5	34	52	50	17	2	42	69	23	3	92	96	16	5	38	117	18	5
6	63	67	68	19	4	68	54	15	6	56	52	17	15	55	32	27	25
7	50	52	59	10	4	60	53	9	10	43	70	6	4	52	64	7	5
8	37	42	112	17	6	48	78	25	9	32	62	19	8	30	77	11	6
9	60	44	40	17	10	36	76	17	4	45	132	17	12	37	106	13	17
10	63	52	113	20	13	51	154	20	12	56	137	46	8	50	153	35	14
11	45	45	67	20	3	46	66	12	8	49	83	10	7	47	82	12	8
12	67	76	65	10	9	72	58	11	7	67	76	14	7	68	61	21	9
13	73	75	114	30	18	65	83	22	14	71	92	21	12	72	91	14	15
14	46	71	86	46	15	74	63	32	9	84	81	41	13	79	82	45	15
15	55	49	66	28	11	51	71	23	12	46	85	21	14	49	91	25	24
Av.	55	60	112	23	12	58	92	21	9	59	102	24	11	55	97	24	13

[a] Inoculum level as determined by the SPC test. Statistical analysis is based on these data.
[b] T-1 inoculum level is determined by the Direct Surface Agar Plate Test.
[c] (T-2 rinse treatment) (T-3 wash treatment) (T-4 sanitize treatment).
[d] These numbers are the average of three replications.

TABLE 2

Bacterial counts per 4 square inch of surface after various cleaning treatments using the swab contact test

Expt. No.	SPC[a]	Finish No. 2B Cleaning treatment				Finish No. 3 Cleaning treatment				Finish No. 4 Cleaning treatment				Finish No. 7 Cleaning treatment			
		T-1[b]	T-2[c]	T-3[c]	T-4[c]	T-1	T-2	T-3	T-4	T-1	T-2	T-3	T-4	T-1	T-2	T-3	T-4
	(× 1,000)	*(× 1,000)*				*(× 1,000)*				*(× 1,000)*				*(× 1,000)*			
1	60	48	352[d]	7[d]	7[d]	16	235	15	11	24	263	6	11	20	301	10	17
2	43	64	83	7	3	32	.....	22	2	32	40	7	1	48	44	5	5
3	68	64	227	10	2	72	243	4	5	44	144	2	3	44	240	5	....
4	58	64	41	11	5	44	31	15	5	24	21	17	3	12	13	6	1
5	34	48	51	17	0	44	29	6	5	40	53	15	3	36	39	11	4
6	63	36	71	21	9	56	41	33	10	88	136	25	5	44	107	15	6
7	50	16	23	5	1	32	36	3	5	32	16	3	1	24	52	5	2
8	37	28	26	6	2	24	21	2	4	28	33	13	5	32	47	6	6
9	60	16	23	9	4	22	63	9	9	18	98	17	7	46	122	11	8
10	63	36	72	11	4	20	139	15	5	36	160	21	9	22	155	21	18
11	45	22	28	14	2	46	25	6	4	18	35	7	2	22	59	4	3
12	67	86	21	7	5	28	24	5	1	62	72	8	5	42	65	5	7
13	73	60	43	8	12	40	11	11	8	38	50	7	5	48	107	7	5
14	46	56	57	21	7	54	25	13	5	74	30	13	3	46	150	19	8
15	55	54	51	7	4	56	89	8	9	28	42	11	8	32	34	7	9
Av.	55	47	78	11	4	39	72	11	6	39	80	11	5	34	102	9	7

[a] Inoculum level as determined by the SPC test. Statistical analysis is based on these data.
[b] T-1 inoculum level as determined by the Swab Contact Test.
[c] (T-2 rinse treatment) (T-3 wash treatment) (T-4 sanitize treatment).
[d] These numbers are the average of three replications.

TABLE 3

Bacterial counts per 4 square inch of surface after various cleaning treatments using the direct agar contact test

Expt. No.	SPC[a]	Finish No. 2B Cleaning treatment				Finish No. 3 Cleaning treatment				Finish No. 4 Cleaning treatment				Finish No. 7 Cleaning treatment			
		T-1[b]	T-2[c]	T-3[c]	T-4[c]	T-1	T-2	T-3	T-4	T-1	T-2	T-3	T-4	T-1	T-2	T-3	T-4
	(× 1,000)	*(× 1,000)*				*(× 1,000)*				*(× 1,000)*				*(× 1,000)*			
1	60	21	67[d]	5[d]	4[d]	27	29	3	7	32	37	11	6	15	62	23	9
2	43	36	30	2	0	29	21	3	1	16	27	7	2	31	43	4	5
3	68	39	136	2	1	32	98	11	1	41	93	1	3	21	133	6	0
4	58	26	28	5	2	21	28	4	0	29	21	5	1	23	20	4	3
5	34	20	13	0	0	9	25	5	1	20	22	1	2	24	22	9	1
6	63	29	19	5	0	45	23	2	1	46	38	10	5	27	41	10	2
7	50	22	23	1	1	32	25	2	1	30	24	3	0	20	51	2	1
8	37	24	23	4	2	16	22	6	3	28	25	7	3	11	28	3	3
9	60	23	27	2	3	19	47	13	1	16	64	7	1	23	47	8	3
10	63	13	68	7	3	26	97	6	2	40	94	19	3	19	81	14	8
11	45	26	25	5	1	18	20	3	1	19	57	6	1	17	41	4	0
12	67	35	13	2	1	40	29	7	2	51	20	10	1	34	37	16	7
13	73	31	43	5	5	35	30	9	4	36	47	3	4	33	70	3	12
14	46	47	31	14	6	48	22	12	3	31	52	23	2	32	52	20	9
15	55	37	53	7	5	68	62	8	5	19	62	6	10	23	75	16	15
Av.	55	29	40	4	2	28	39	6	2	30	46	8	3	24	54	9	5

[a] Inoculum level as determined by the SPC test. Statistical analysis is based on these data.
[b] T-1 inoculum level as determined by the Direct Agar Contact Test.
[c] (T-2 rinse treatment) (T-3 wash treatment) (T-4 sanitize treatment).
[d] These numbers are the average of three replications.

TABLE 4
Summary of results of analysis of variances at 5% significance level

Cleaning treatment	
	Direct Surface Agar Plate Test
T-2[a]	No significant difference in cleanability of 2B, 3, 4, and 7 finishes
T-3	No significant difference in cleanability of 2B, 3, 4, and 7 finishes
T-4	No significant difference in cleanability of 2B, 3, 4, and 7 finishes
	Swab Contact Test
T-2[b]	A significant difference in cleanability of 2B, 3, 4, and 7 finishes
T-3	No significant difference in cleanability of 2B, 3, 4, and 7 finishes
T-4	No significant difference in cleanability of 2B, 3, 4, and 7 finishes
	Direct Agar Contact Test
T-2	A significant difference in cleanability of 2B, 3, 4, and 7 finishes
T-3	A significant difference in cleanability of 2B, 3, 4, and 7 finishes
T-4	A significant difference in cleanability of 2B, 3, 4, and 7 finishes

[a] (T-2 = Pre-rinse + rinse), (T-3 = T-2 + det. wash and rinse), (T-4 = T-3 and Cl. sanitization).

[b] No significant difference at the 1% level.

bating conditions differ in the DSAP from the Standard Plate Counting procedure as recommended by *Standard Methods* (1) does not materially influence the growth and detection of the organism employed, as an analysis using Fisher's "t" test to compare these tests indicated no significant difference using the control data given in Treatment T-1.

Although no significant difference was observed among the four finishes, after exposure to any specific cleaning treatment with the DSAP test, it is important to note that the more nearly the experimental cleaning treatment approached the recommended practice of washing and sanitizing, the better the degree of cleanliness as indicated by the decrease in bacterial population (Table 5). This is clearly indicated in the DSAP test by the decrease in count on a 2B finish from 112 to 23 to 12 per sq. in. (gr. av.), after T-2, T-3, and T-4, respectively. On a No. 3, 4, and 7 finish the counts decreased following the improved cleaning cycle as follows: 92-21-9, 102-24-11, and 97-24-13, respectively. On a percentage basis, using the grand average values, detergent washing (T-3) reduced the count from that obtained on rinsing by 80%; washing followed by sanitizing reduced the count obtained on rinsing by 89%. Although this represents only a 9% decrease based on the number remaining after rinsing, sanitization actually decreased the number remaining after washing by about 50%.

The data in Table 5 indicate that compliance with the minimum recommended standard (50/4 sq. in.) was obtained in only 16% of the trials on the 2B finish after the mildest cleaning treatment; under the same conditions, the No. 3, 4, and 7 finishes complied 14, 13, and 16% of the time, respectively. It is apparent from this that in the great majority of the trials all finishes were improperly cleaned using experimental mild pre-rinse, rinse treatment. Detergent washing reduced the bacterial load considerably from that observed after rinsing. Compliance with the standards was observed in 100, 91, 96, and 93% of the trials on the

TABLE 5

Summary table showing average bacteria counts and the per cent compliance with recommended maximum standards

	Direct Surface Agar Plate				Swab Contact				Direct Agar Contact			
	Finish No.				Finish No.				Finish No.			
	2B	3	4	7	2B	3	4	7	2B	3	4	7
	Prerinse and rinse (T-2)											
% Accept[a]	16	14	13	16	56	63	53	38	67	73	64	49
High[b]	255	195	224	211	352	243	263	301	136	97	64	133
Low	40	53	28	28	21	11	21	13	13	21	20	20
Average	112	92	102	97	78	72	80	102	40	39	46	54
	Rinse and wash (T-3)											
% Accept	100	91	96	93	100	100	100	100	100	100	100	98
High	46	32	77	75	21	33	25	21	14	13	23	23
Low	10	9	6	7	5	2	2	4	0	2	1	2
Average	23	21	24	24	11	11	11	9	4	6	8	9
	Rinse, wash, and sanitize (T-4)											
% Accept	100	100	100	98	100	100	100	100	100	100	100	100
High	46	19	31	35	12	11	11	18	6	7	10	15
Low	2	3	1	2	0	1	1	1	0	0	0	0
Average	12	9	11	13	4	6	5	7	2	2	3	5

[a] Per cent less than the maxmum recommended level of 50 per 4 sq. in.; based on 45 analyses in most cases.

[b] From top to bottom these figures represent the highest count per 4 sq. in. (average), the lowest count (average), and the grand average count taken on 15 experimental trials, using three replications per trial.

2B, 3, 4, and 7 finishes, respectively. Although satisfactory compliance was observed in the majority of instances after rinsing and washing without sanitization, it is important to note that chlorine sanitization provided the additional kill to make it possible to obtain 100% compliance on the 2B, 3, and 4 finishes and 98% compliance on the No. 7 finish. On the basis of the statistical analysis employed, no significant difference can be attached to any of the actual or percentage figures within the same cleaning treatment. The high rate of compliance for all finishes after a complete cleaning cycle, as contrasted with the low rate of compliance for all surfaces after only a poor rinsing, indicates the desirability and need for adherence to the recommended cycle to insure the desired end point. Since the experimental cleaning techniques approximated CIP spray-cleaning principles in a minimum manner, and since the data showed excellent compliance (average count of 4 per 4 sq. in.) after a complete cleaning cycle, the feasibility of successful CIP operations using 2B, 3, 4, or 7 finishes is indicated.

Swab Contact Test. Using the Swab Contact Method as a technique to measure cleanability, as expressed by the number of bacteria which can be removed by swabbing, a difference at the 5% level was observed among the four finishes examined after T-2, but no difference at the 5% level was observed after T-3 and T-4. The criterion was 2.69 and the F value was 2.848 in the T-2 series; these values are in very close agreement, considering the biological nature of the study, and indicate that the postulated difference may be very slight. The distribution of the grand averages, as given in Table 2 for T-2 (78-72-80-102), are suggestive

of this close agreement with regard to cleanability of the four finishes. A closer inspection of the individual data indicates some wide variations which are considered in the analysis of variance pattern and which contribute to the finding of the significant difference observed in T-2. When T-2 is tested by an analysis of variance at the 1% level, no difference among finishes is noted. An attempt to determine the exact locus of this difference in the group was undertaken, using the Multiple Range Test of Duncan (3). However, this test indicated no difference between the four finishes after T-2 when the Swab Test was used.

The actual average counts obtained using the Swab Contact Test are given in Table 5. Where bacterial levels are high (greater than 250/4 sq. in.) the swab test tends to give higher values than either of the other tests. This may be due to crowding, making accurate counting difficult with the DSAP when the bacterial level is greater than about 100. In almost all other instances, the DSAP count was higher than the swab count; this is evidence of the more critical nature of the DSAP test. At low population levels (less than 30/4 sq. in.), the swab test was invariably lower than the DSAP, indicating the failure of the former to release bacteria from the swab or to remove them from the surface, when present in low concentrations. It is for this latter reason that a high percentage of acceptable counts was obtained after T-2 (56-63-53-38%). The inability of the swab test to detect low levels of bacterial contamination also explains the 100% acceptability observed after T-3 in all cases. As was evident in the DSAP data, washing with detergent removed the greatest majority (86%) of the bacteria which remained on rinsing; sanitization reduced the level to 95% on the same basis. Sanitizing per se, however, reduced the contamination level about 64% in the case of the 2B, 3, and 4 finish. This compares favorably with the results obtained using the DSAP test.

Direct Agar Contact. The results obtained with the Direct Agar Contact Test are shown in Table 3. A significant difference at the 5% level was found between the 2B, 3, 4, and 7 finishes after T-2, T-3, and T-4. The inefficiency of the Direct Agar Contact method in establishing close contact between the panel and agar surface is, in part, responsible for the different findings obtained with this test, as compared to the DSAP and swab tests. Visible air bubbles were occasionally entrapped between the steel surface and the agar; this prevented the intimate contact on which this test is dependent. The failure to establish contact with the bacteria on these areas would result in inefficient cell recovery. The two 5-sec. contact periods also were inadequate to effect bacterial removal. The inefficiency of bacterial removal is clearly indicated by the data in Tables 3 and 5; in every instance the counts are less than those obtained with the DSAP test. Because of these limitations, the results obtained with this test should not be interpreted with respect to relative cleanability of the test finishes.

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INFLUENCE OF VACUUM PASTEURIZATION UPON THE FREEZING POINT VALUE, TOTAL SOLIDS, AND CONCENTRATION OF FLUID MILK

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SUMMARY

The concentration of milk due to pasteurization in a Vacu-Therm pasteurizer was estimated by freezing point measurements, total solids determinations, and by condensing and trapping the water removed from the milk. Composite samples of raw and pasteurized milk were obtained during 3-hr. processing periods from the balance and surge tanks of the equipment. The temperature of pasteurization and the vacuum level were varied independently from 161 to 175° F. and from 22 to 26 in. When the difference between the temperature of pasteurization and the temperature in the second vacuum chamber exceeded 20° F., water was removed from the milk. Both total solids values and freezing point measurements required adjustment, to be most useful in estimating water removal. The freezing point technique appears to be the most economical, precise, and sensitive method for estimating concentration or water removal of vacuum pasteurized milk.

To protect against flavor defects in market milk, efforts have been made recently to develop equipment for the removal of off-flavors. One effort in this direction is the use of vacuum equipment in conjunction with the HTST pasteurizer. With the acceptance of the value of vacuum pasteurization (4, 8) by the dairy industry, public health authorities became concerned about the effects of vacuum treatment in regard to adulteration of the milk. The work of Bellamy (2), using total solids as a criterion, indicated that milk treated in the Vacu-Therm[1] may be slightly concentrated. The work of Elsdon and Stubbs (3), Parker and Spackman (6), and Van Slyke and Keeler (10) suggests that the freezing-point depression of milk may be decreased by removal of dissolved gases under vacuum. Pinkerton and Peters (7) have reported that pasteurization decreased the freezing-point depression of milk. Sato *et al.* (9) found no change in the freezing-point value of milk after pasteurization. The type of pasteurizer employed is not mentioned in either report.

This study was undertaken to determine the effect of vacuum pasteurization, without steam injection, upon the total solids and the freezing-point value of milk, and to estimate the amount of water removed from milk by vacuum-pasteurization equipment.

EXPERIMENTAL PROCEDURE

A 4,000-lb.-per-hour Vacu-Therm pasteurizer equipped with two vacuum chambers was used in this work. The vapors from the second chamber are drawn into the first chamber and then through a vacuum pump after being condensed in the condensate section of the press. For control purposes, the two vacuum chambers were disconnected from the pasteurizer and the Vacu-Therm converted into a regular short-time pasteurizer.

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[1] Vacu-Therm Pasteurizer, De Laval Separator Co., Poughkeepsie, N. Y.

Separate lots of milk were pasteurized at 161, 165, 170, and 175° F. and subjected to 22, 24, and 26 in. of vacuum, measured by gauge pressure, at each pasteurization temperature. The milk was homogenized at 2,000 lb. pressure after vacuum treatment and collected in a surge tank. The equipment was adjusted for one pasteurization temperature and one vacuum setting and operated continuously for not less than 3 hr. Raw samples of each milk to be treated were obtained from the raw milk balance tank at 10-min. intervals and composited. Pasteurized samples of each treated milk were obtained from the surge tank at 10-min. intervals and composited. No samples were taken the first and last 30 min. of a trial, to avoid any possible dilution with water. Precautions were taken to prevent any recirculation of milk through the pasteurizer. The temperature drop of the milk was defined as the difference between the pasteurization temperature and the temperature of the milk in the second vacuum chamber.

Total solids. Total solids were determined in duplicate for all samples of milk by the Mojonnier method (5). The difference between the total solids values of the raw and pasteurized samples divided by the total solids value of the raw sample, multiplied by 100, resulted in the calculated percentage change in composition.

Freezing-point values. The freezing-point values were determined in duplicate for all samples of milk by the Hortvet method (1). The calculated percentage change in composition was determined by dividing the freezing-point value of the raw sample into the difference between the freezing-point values of the raw and pasteurized samples and multiplying the quotient by 100. Minus values indicated apparent dilution, whereas plus values indicated apparent concentration.

Condensate. A measurement of the condensate collected after pasteurizing milks at various temperatures and vacuums was obtained by placing a calibrated trap in the vacuum line between the vapor-condensing section of the press and the vacuum pump. The amount of condensate was recorded in gallons per hour. This value was divided by the rated capacity of the Vacu-Therm and the quotient multiplied by 100, to determine the percentage change in composition of the milk. Since the vacuum chambers were disconnected during the pasteurization of control samples, no condensate was collected from these milks.

RESULTS AND DISCUSSION

The total solids and freezing-point and condensate data are presented in Table 1. The control samples are those pasteurized by the conventional HTST method (no vacuum) and the vacuum-treated samples were those pasteurized in the Vacu-Therm.

Total solids. The total solids values were higher in the vacuum-pasteurized samples than in the corresponding raw samples, regardless of the treatment, except for one sample where the small difference was attributed to experimental error. When the temperature drop was greater than 20° F., the total solids content of vacuum-pasteurized samples increased markedly. Samples pasteurized in a HTST pasteurizer showed an increase in total solids of the same magnitude as those with a temperature drop of less than 20° F. which were pasteurized

TABLE 1

Influence of vacuum pasteurization (without steam injection) upon the total solids, freezing points, and concentration of fluid milk

Inches of vacuum gauge	Past. temp.	2nd chamber temp.	Heat differential	Total solids			Freezing points			Per cent concentration measured by		
				Raw	Past.	Diff.	Raw	Past.	Diff.	Total solids	Freezing point	Condensate
	(°F.)			(%)			−° C.	−° C.	−° C.			
HTST												
0	161	.....	0.0	13.10	13.14	0.04	0.533	0.533	0.000	0.31	0.00	0.00
0	165	.....	0.0	13.09	13.14	0.05	0.531	0.531	0.000	0.38	0.00	0.00
0	170	.....	0.0	12.94	13.00	0.06	0.533	0.535	0.002	0.46	0.38	0.00
0	175	.....	0.0	12.89	12.95	0.06	0.530	0.531	0.001	0.47	0.19	0.00
Vacu-Therm												
22	161	159.0	2.0	13.18	13.25	0.07	0.534	0.527	−0.007	0.53	−1.31	0.05
22	165	161.0	4.0	12.95	13.00	0.05	0.534	0.528	−0.006	0.39	−1.12	0.04
22	170	162.0	8.0	12.90	12.96	0.06	0.540	0.534	−0.006	0.47	−1.11	0.02
22	175	162.0	13.0	12.78	12.85	0.07	0.538	0.532	−0.006	0.55	−1.12	0.05
24	161	152.5	8.5	12.95	13.01	0.06	0.531	0.524	−0.007	0.46	−1.32	0.05
24	165	153.0	12.0	13.05	13.07	0.02	0.537	0.533	−0.004	0.15	−0.74	0.04
24	170	151.0	19.0	12.73	12.71	−0.02	0.534	0.530	−0.004	−0.16	−0.75	0.09
24	175	150.0	25.0	12.78	12.99	0.21	0.539	0.539	0.000	1.64	0.00	1.32
26	161	135.0	26.0	13.00	13.26	0.26	0.536	0.540	0.004	2.00	0.75	1.28
26	165	138.5	26.5	12.81	13.05	0.24	0.534	0.537	0.003	1.87	0.56	1.52
26	170	137.0	30.0	12.83	13.06	0.23	0.537	0.541	0.004	1.79	0.74	1.60
26	175	142.5	32.5	12.92	13.16	0.24	0.535	0.541	0.006	1.86	1.12	1.96

in the Vacu-Therm. Since it is impossible for total solids to get into a HTST pasteurizer and/or water to get out of it, this increase in total solids was considered an apparent increase. This apparent increase of 0.05% (average of Samples 1–5 in Table 2) was attributed to less selective drainage of the homogenized milk from the weighing pipettes. Unhomogenized milk will drain selectively from a pipette, proportionally larger amounts of fat than other solids remaining in the pipette, yielding a lower total solids value in unhomogenized milk. Table 2 shows the effect of homogenization on the total solids value of composite samples of 3-hr. pasteurization periods with HTST and vacuum pasteurizers. Samples were obtained as outlined previously in the Methods section of this paper.

TABLE 2

Effect of homogenization on the total solids value of pasteurized milk

Trial	Homogenized	Method of pasteurization	Freezing point			Total solids		
			Raw	Past.	Diff.	Raw	Past.	Diff.
			(−°C.)	(−°C.)	(°C.)	(%)		
1	Yes	HTST	0.533	0.533	0.000	13.10	13.14	0.04
2	Yes	HTST	0.531	0.531	0.000	13.09	13.14	0.05
3	Yes	HTST	0.533	0.535	0.002	12.94	13.00	0.06
4	Yes	HTST	0.530	0.531	0.001	12.89	12.95	0.06
5	Yes	Vacuum	0.532	0.527	−0.005	12.33	12.38	0.05
6	No	Vacuum	0.538	0.532	−0.006	12.69	12.70	0.01
7	No	HTST	0.532	0.532	0.000	12.52	12.48	−0.04
8	No	Vacuum	0.533	0.529	−0.004	12.50	12.51	0.01
9	No	HTST	0.530	0.531	0.001	12.36	12.35	−0.01

Freezing-point values. The freezing-point values of HTST-pasteurized samples were similar to those of the raw milk, as shown in Tables 1 and 2. The freezing-point values of vacuum-pasteurized samples were not similar to those of the raw milks. Vacuum pasteurization with a temperature drop of less than 20° F. raised the freezing-point value (decreased depression) 0.006° C., which is equivalent to 1% of added water. As no water entered the milk, this is an apparent dilution. The same temperatures of pasteurization in a HTST pasteurizer showed no change in the freezing-point value of the pasteurized samples, ruling out milk-salt precipitation due to the application of heat as an explanation for the change in freezing-point value of the vacuum-pasteurized samples. This change is attributed to the removal of dissolved gases from the milk by vacuum pasteurization. When the temperature drop was 20° F. or greater, the rise in the freezing-point value due to the removal of dissolved gases was balanced or exceeded by concentration of the milk, as shown in Table 1.

Concentration. The percentage concentration of pasteurized milk samples was calculated from total solids, freezing point, and condensate data, as shown in Table 1. The condensate, or water removed from the milk during pasteurization, was nil for vacuum-pasteurized samples where the temperature drop was less than 20° F. With a temperature drop of 25° F. and greater, the volume of condensate collected showed that concentration of the milk occurred and increased in a nonlinear manner as the temperature drop increased.

TABLE 3

Concentration of vacuum-pasteurized milk corrected for a total solids value of 0.05% for raw milk and a freezing-point value of 0.006° C. for pasteurized milk

Inches of vacuum gauge	Past. temp.	2nd chamber temp.	Heat differential	Total solids			Frezing point			Per cent concentration measured by		
				Raw	Past.	Diff.	Raw	Past.	Diff.	Total solids	Freezing point	Condensate
	(°F.)			(%)			(−°C.)	(−°C.)	(°C.)			
HTST												
0	161	.....	0.0	13.15	13.14	−0.01	0.533	0.533	0.000	−0.08	0.00	0.00
0	165	.....	0.0	13.14	13.14	0.00	0.531	0.531	0.000	0.00	0.00	0.00
0	170	.....	0.0	12.99	13.00	0.01	0.533	0.535	0.002	0.08	0.38	0.00
0	175	.....	0.0	12.94	12.95	0.01	0.530	0.531	0.001	0.08	0.19	0.00
Vacu-Therm												
22	161	159.0	2.0	13.23	13.25	0.02	0.534	0.533	−0.001	0.15	−0.19	0.05
22	165	161.0	4.0	13.00	13.00	0.00	0.534	0.534	0.000	0.00	0.00	0.04
22	170	162.0	8.0	12.95	12.96	0.01	0.540	0.540	0.000	0.00	0.00	0.02
22	175	162.0	13.0	12.83	12.85	0.02	0.538	0.538	0.000	0.16	0.00	0.05
24	161	152.5	8.5	13.00	13.01	0.01	0.531	0.530	−0.001	0.08	−0.19	0.05
24	165	153.0	12.0	13.10	13.07	−0.03	0.537	0.539	0.002	−0.23	0.37	0.04
24	170	151.0	19.0	12.78	12.71	−0.07	0.534	0.536	0.002	−0.55	0.31	0.09
24	175	150.0	25.0	12.83	12.99	0.16	0.539	0.545	0.006	1.25	1.11	1.32
26	161	135.0	26.0	13.05	13.26	0.21	0.536	0.546	0.010	1.61	1.87	1.28
26	165	138.5	26.5	12.86	13.05	0.19	0.534	0.543	0.009	1.48	1.69	1.52
26	170	137.0	30.0	12.88	13.06	0.18	0.537	0.547	0.010	1.40	1.86	1.60
26	175	142.5	32.5	12.97	13.16	0.19	0.535	0.547	0.012	1.46	2.24	1.96

The concentration measured by total solids was greater than that found by measuring the condensate volume. When the apparent concentration attributed to selective drainage of homogenized milk from pipettes used in the total solids method was corrected (Table 3), by increasing the raw milk total solids values 0.05%, concentration calculated by the two methods was in closer agreement.

The concentration measured by freezing-point value was less than that found by measuring the condensate volume. When the apparent dilution attributed to the removal of dissolved gases from the vacuum-pasteurized milk was corrected (Table 3), by decreasing the freezing-point value 0.006° C., concentration calculated by the two methods was in closer agreement.

The concentration of milk in vacuum pasteurizers can be estimated using any of the three methods presented here if the correction factors are applied for the total solids (homogenized milk) and freezing-point value techniques, as shown in Tables 1 and 3. Later models of the Vacu-Therm pasteurizer are not equipped with a press containing a condenser section, which makes the condensate method impractical. The freezing-point method, with correction factor, appears to be the most economical, precise, and sensitive technique for determining concentration.

CONCLUSIONS

Concentration does not take place in a vacuum pasteurizer of the type used in this work until the temperature drop exceeds 20° F. Water is not removed from the milk when the equipment is operated as the manufacturer suggests. At greater vacuum levels or higher temperatures (which cause a temperature drop of more than 20° F.), sometimes used in flavor control, water is removed from the milk and concentration occurs.

Freezing-point values must be corrected for apparent dilution, and total solids values (homogenized milk) for apparent concentration, to yield the same information as measurements of the actual water removed from the milk during processing.

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DETERMINATION OF CURD MAKING QUALITY OF NONFAT DRY MILK

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SUMMARY

A method using similar laboratory vats was developed for determining the curd making quality of nonfat dry milk. Curds were made from an unknown and from a control nonfat dry milk by identical procedures and were scored for quality and classified into grades. Accuracy was enhanced by cancellation of curd defects due to defective starters or other causes. A high degree of correlation was found between cottage cheese curds made in laboratory and pilot size vats. A low correlation was found between whey protein nitrogen of nonfat dry milk and curd making quality; and between curd tension of nonfat dry milk and curd making quality.

Several processing plants engaged in making rennet type cottage curd from nonfat dry milk (NDM) have reported experiences with curd shattering, slow whey expulsion, and high curd losses during cooking. The cooked curd was soft, and large amounts of free whey drained off during storage at 45° F. Analyses of the above dry milk products for soluble whey protein nitrogen (WPN) (8) and rennet-HCl curd tension at pH 6.0 (3, 7) indicated high quality, low heat NDM (4, 9).

When cottage curd was made in pilot vats from the aforementioned dry milks, using 350 lb. of reconstituted cheese-milk, the results were similar to those reported by the commercial processors. The reconstituted cheese-milk formed a firm coagulum, but after cutting at pH 4.70 the curd softened during cooking at pH 4.60 to 4.70. These observations indicated that the cottage curd making quality of NDM was not always reflected by either WPN or rennet-HCl curd tension values.

It was found that if cottage curd was made from a control and unknown NDM simultaneously in laboratory vats, some of the variables of curd making were cancelled and accurate appraisal of the curd making quality of the unknown powder was permitted. This paper was confined to a description of the laboratory method; to a comparison between laboratory and pilot curd making operations; and to the relation of soluble WPN content and of rennet-HCl curd tension value of NDM to curd making quality.

METHOD

Curd was made simultaneously from the unknown and from a control NDM as follows:

Equipment and Materials

Mixed strain lactic cheese culture (dried). Purchased.
Autoclave, Scanlan-Morris type A-420.
Culture incubator set at 71 ± 1° F.

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Equipment for pasteurizing the reconstituted starter-milk and incubating the starter. A Nu-Processor vat was used.

Rennet extract.

Beckman, Model H pH meter with external glass and reference electrodes.

Standard buffer solution for calibration of pH meter.

Pilot, spray type, 50-gal. capacity, cheese vat, 22 by 36 by 17 in.

Control NDM having excellent curd making quality. Made from high quality skimmilk by a cumulated heat treatment approximately equivalent to pasteurization of fluid milk at 143° F. for 30 min.

Similar laboratory cheese vats. Two sets of twin compartment stainless vats were used; each vat compartment was 16 by 8½ by 8½ in.

Pair of ¾-in. curd knives. One set of similar laboratory vats and a pair of curd knives are shown in Figure 1.

Curd strainer, diameter and depth 8 in.

Water bath adjustable from 90 to 130° F. The pilot cheese vat was used as a water bath and held two sets of the laboratory vats.

Procedure. Lactic liquid culture was prepared from the dried culture by adding it to sterilized composite whole milk obtained from the Virginia Polytechnic Institute herd, and incubating at 71 ± 1° F. until the milk was coagulated. The liquid culture was transferred daily, using 0.5% inoculum, and was incubated at 71 ± 1° F. for 15 ± 1 hr. After incubation, the culture was chilled

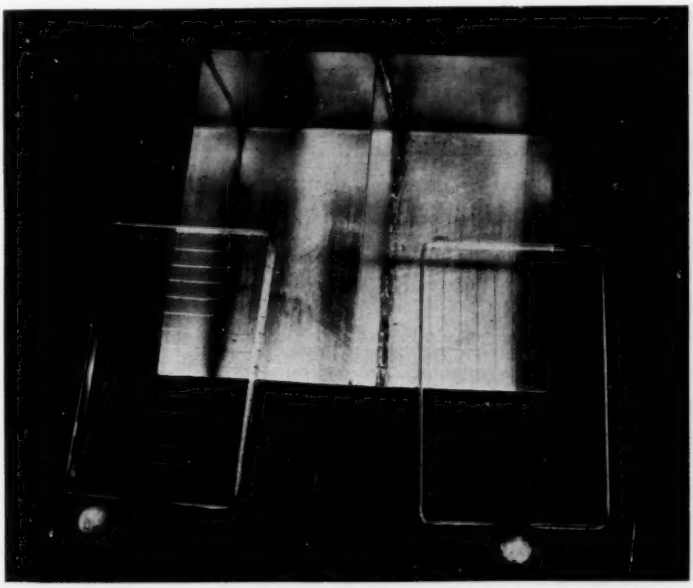

FIG. 1. Similar laboratory cheese vats and curd knives for determining the curd making quality of NDM.

and held in an ice bath until used.

Starter-milk and cheese-milk for each vat of curd were made from the same NDM product. Both were reconstituted to contain 10.0 to 11.0% solids. The starter-milk was pasteurized at 155° F. for 30 min. This pasteurizing procedure was used to avoid a high per cent denaturation of the serum proteins (4). Starter was prepared from the pasteurized milk by cooling to 70° F., inoculating with 1.0% liquid culture, and incubating for 12 to 14 hr. at 71 ± 1° F.

Seven pounds of the starter were thoroughly mixed by vigorous stirring into 25 lb. of the unpasteurized, freshly reconstituted cheese-milk, and the temperature was adjusted to 95° F. Thirty minutes after mixing, rennet extract was added at the rate of 0.25 ml. per 100 lb. of milk plus starter.

The set milk in each vat was left undisturbed at 95° F. until the pH of the curd was 4.70, then it was cut into ¾-in. cubes and the temperature of the whey was increased to 99° F. The whey was held at this temperature until the pH of the curd was 4.60. At this pH, cooking was started by slowly increasing the temperature. A final cooking temperature of 120° F. was reached in about 90 min., and the curd was held at this temperature for 30 min.

After cooking, the whey was removed and the curd was washed, using two 25-lb. portions of wash water at 70 and 50° F., respectively. (At this time the curd making quality of the unknown NDM may be estimated from its relative degree of firmness and shattering.) The washed curd was drained overnight at 50° F.

The curd from each vat was packaged in 12-oz. cartons, stored at 40° F. for 24 hr., and scored for body and texture and for color and appearance by two experienced judges. The score-card and guide recommended by the Cottage Cheese Score-Card Committee of the American Dairy Science Association was used (1). The ranges of score deductions and corresponding grades of curd were: 0.0 to 1.5—excellent; 1.6 to 2.5—good; 2.6 to 3.5—fair; 3.6 to 4.5—poor; 4.6 to 5.5—very poor; and 5.6 or more—unusable.

The curd making quality of the unknown dry milk was assessed by comparing its score deductions and grade with those of the control dry milk. The method was considered versatile. The procedures may be altered to duplicate those in current use.

EXPERIMENTAL PROCEDURE

Relation of curd made in laboratory vats to curd made in a pilot vat. Fourteen pairs of vats of reconstituted cheese-milk were made into cottage curd in the laboratory and pilot vats, using 25 and 350 lb. of milk, respectively. The curds were made essentially by the above procedure. The amounts of starter and of rennet added to the larger vats of milk were increased proportionately, and curds were made which varied widely in moisture.

After packaging and storing for 24 hr. at 40° F., each curd from each pair of vats was evaluated for defects of body and texture and of color and appearance (1) and was analyzed for moisture (2).

The data were plotted and correlated (6). The relationship between the score deductions and between the per cent moisture of the curds which were made in the laboratory and pilot vats is shown in Figures 2 and 3, respectively. The high degree of similarity found between these pairs of curds was demonstrated by the relatively high correlation coefficients of +0.895 (when score deductions were compared) and +0.844 (when moisture contents were compared).

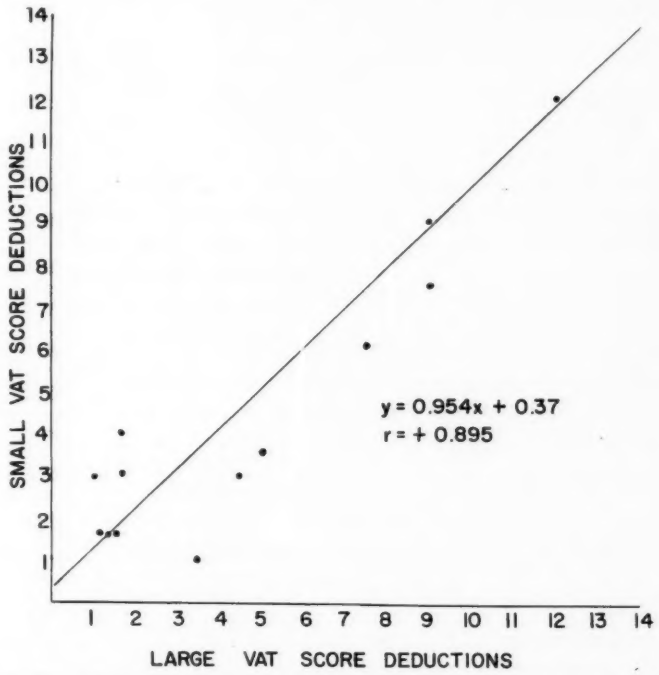

FIG. 2. Relationship between score deductions on body and texture and on color and appearance of cottage curd made in the laboratory and pilot vats.

Relation of soluble WPN and rennet-HCl curd tension to curd making quality. Nineteen commercially produced extra grade, low heat NDM products were tested for soluble WPN (8), rennet-HCl curd tension at pH 6.0 (3, 7), and curd making quality by the above laboratory method. Curd score deductions were made on body and texture and on color and appearance (1), and the curds were graded as outlined in the procedure.

The results were summarized in Table 1. The soluble WPN varied from 8.7 to 3.7 mg. and curd tension from 148 to 10 g. When the WPN content ranged from 8.6 to 7.1 mg. and the curd tension from 148 to 71 g., the curd score deductions varied from 0.7 to 9.5 and the curd grades from excellent to unusable. These 15 dry milks were classified as low heat products.

When the WPN content varied from 5.2 to 3.7 mg. and the curd tension from 44 to 10 g., the curd score deductions varied from 5.0 to 7.0 and the curd grades from very poor to unusable. These four dry milks would not be classified as low heat products (9).

The curds which were made from the control dry milk, while making curd from each of the 19 commercial powders, were given score deductions which ranged from 0.0 to 1.0. The WPN content of the control powder was 8.5 mg. and the curd tension 140 g.

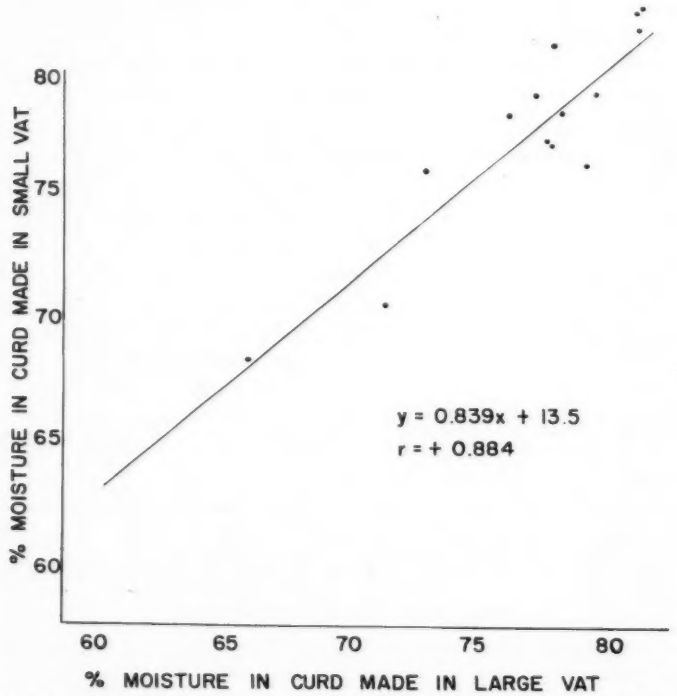

FIG. 3. Relationship between per cent moisture in cottage curd made in the laboratory and pilot vats.

The WPN values and the curd tension values of the 19 commercially produced dry milks were plotted against their corresponding curd score deductions, and the correlation coefficients were −.380 and −.321, respectively. However, when the WPN values and the curd tension values of the 15 low heat dry milks (Table 1) were correlated with their corresponding curd score deductions, still lower degrees of correlation were found. The correlation coefficients were −.033 and −.061, respectively.

None of the above correlation coefficients indicated close relationships. It was of interest, however, that the degree of correlation between the WPN values

and between the curd tension values of all 19 dry milks and their corresponding score deductions was higher than the degree of correlation between the WPN values and between the curd tension values of the 15 low heat dry milks and their corresponding score deductions. The high correlation was attributed to the effect of the four dry milks which had relatively low WPN and curd tension values

TABLE 1

Ranges of WPN and rennet-HCl curd tension of NDM and of score deductions and grades of cottage curd

No. of powders	WPN	Curd tension	Score deductions	Grade
	(mg.)	*(g.)*		
15	8.6–7.1	148–71	0.7–9.5	Excellent to unusable
4	5.2–3.7	44–10	5.0–7.0	Very poor to unusable

and which were not classified as low heat, cottage type powders. The curds which were made from these four dry milks were given high score deductions, but the scatter of the scores was less than the scatter of the scores of the curds which were made from the 15 low heat dry milks.

The curd making quality of the dry milks which had high soluble WPN values (> 7.0 mg.) and high rennet-HCl curd tension values (> 70 g.) and which were classified as low heat products varied widely. On the basis of these results, neither of these values were satisfactory for completely evaluating NDM for curd making quality. However, either of these values appeared to be useful for classifying dry milks according to the degree of cumulated heat treatment received during processing (5).

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GENETIC AND PHENOTYPIC RELATIONSHIPS BETWEEN CLINICAL MASTITIS, LABORATORY CRITERIA, AND UDDER HEIGHT[1]

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SUMMARY

Genetic aspects of mastitis resistance were investigated where quantitative scores were determined for clinical mastitis, bacterial infection, and leucocyte count. Heritability and repeatability estimates were obtained for these scores, and phenotypic and genetic correlations between scores were estimated. Correlations also were obtained between udder height and the scores for clinical mastitis, bacterial infection, and leucocyte count.

Heritability estimates for clinical mastitis obtained from the paternal sister correlation and daughter-dam regression were inconsistent. Repeatability for clinical mastitis was estimated at .31. Estimated genetic correlations from the two analyses were .29 and .23 for clinical mastitis with bacterial infection, and .80 and .98 for clinical mastitis with leucocyte count. Udder height was found to be negatively correlated with scores for clinical mastitis, bacterial infection, and leucocyte count.

Environmental and managemental influences generally are conceded to be important causes of mastitis, and there seems little doubt that strict attention to managemental details would sharply reduce mastitis incidence in many herds. However, there is also considerable variation in the occurrence of mastitis between cows managed alike in the same herd, and between herds where the management appears to be much the same. These observations indicate that genetic differences also may be of considerable importance in determining the incidence of mastitis, and Lush (6) and Legates and Grinnells (5) have reported heritability estimates for mastitis resistance of .38 and .27, respectively.

This paper reports further study aimed at a more detailed assessment of the genetic and phenotypic aspects of clinical mastitis. Additional data from laboratory examinations of the foremilk for leucocyte count and presence of bacteria also were obtained to bolster the clinical histories. Whether this additional information would permit more rapid genetic improvement depends largely upon the genetic relationships between laboratory criteria and clinical mastitis. These relationships were studied, as was the relationship between udder height and mastitis. Although the pendulous udder has long been considered as predisposing to mastitis, there is no known experimental evidence to substantiate such a relationship.

EXPERIMENTAL PROCEDURE

Nature of the data. Data for this study were collected from November, 1954, to January, 1958, from four state-owned dairy herds. Two of the herds included animals of the Ayrshire, Guernsey, Holstein, and Jersey breeds, whereas the

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remaining herds were made up entirely of Holsteins. During the experimental period, 422 cows terminated 682 lactations of 7 mo. duration or longer. Clinical histories, monthly composite foremilk samples, and hock and udder measurements for these 682 lactations constituted the basis of this study.

The terms mastitis and clinical mastitis are used herein as synonyms and are defined as the abnormal appearance of the udder or its secretion. Clinical mastitis was diagnosed by means of the strip cup, or by observation of visible inflammation of the udder.

Monthly individual composite foremilk samples were taken from each cow in milk on the date a herd was sampled. Composite samples were taken even when clinical symptoms were present in one or more quarters. These samples were cultured on blood agar plates for the detection of bacteria, and stained for the enumeration of leucocytes. Milk samples were not incubated prior to plating. *Streptococcus agalactiae, Streptococcus dysgalactiae, Streptococcus uberis, Streptococcus pyogenes,* and gram-negative rods were identified by fermentation reactions. Streptococci, other than those listed above, were not further identified. Staphylococci were classed as hemolytic or nonhemolytic according to their action on the blood plates.

Udder and hock height measurements were taken from 30 to 60 days postpartum. The average of duplicate measurements taken on the same date was used. Measurements were taken from the lowest part of the udder floor to the barn floor, and from the point of the hock to the barn floor. These data were collected just prior to milking while the udder was distended.

Modification of the data. This investigation differed from those conducted previously (5, 6), in that an attempt was made to rate individual lactations on a continuous scale of mastitis resistance. Unfortunately, a satisfactory continuous scale could not be achieved for scores concerning clinical mastitis and bacterial infection, as no means was available for properly assessing the severity or intensity of clinical attacks or bacterial infections. Therefore, the quantitative system used for these scores rested heavily upon differences in incidence of occurrence. The manner of scoring for clinical mastitis, bacterial infection, and leucocyte count is described below:

(1) *Clinical mastitis.* The score for clinical mastitis was the percentage of months of the lactation during which the cow had clinical mastitis one or more times. Range of possible scores was 0 to 100.

(2) *Bacterial infection.* The score assigned an individual for bacterial infection was calculated by scoring each monthly milk sample as either zero, one, or two for bacterial infection. Scores of two were assigned samples found to contain any of the three common mastitic streptococci, i.e., *S. agalactiae, S. dysgalactiae,* and *S. uberis.* Infections by all other organisms considered relevant to mastitis, largely hemolytic staphylococci, were given a weight of one point. Scores of zero were assigned samples showing no growth or growth of organisms considered irrelevant to mastitis. The scores for individual monthly samples were summed for the lactation, and this total was multiplied by ten and divided by the number of samples, to put all lactations on an equal basis regardless of their length. Range of possible scores was 0 to 20.

(3) *Leucocyte score.* The leucocyte score was computed by summing the logarithms of the monthly leucocyte counts and dividing this total by the number of monthly observations for the lactation. The score was, therefore, the logarithm of the geometric mean leucocyte count. In this case, the range of scores is not fixed, but for this study was 4.193 to 6.745.

Before proceeding with the analyses, the data were examined for the presence of age differences. This was done by determining the regression of the three scores just described on lactation number and lactation number squared. The latter term was used in order to test for curvilinearity. The regression was obtained on a within year, herd, and breed basis. The regression coefficients, their standard errors, and levels of significance are given in Table 1. In

TABLE 1

Linear (b_1) and curvilinear (b_2) regression of clinical mastitis, bacterial infection, and leucocyte count on lactation number

Score	Mean score	$b_1 \pm s_{b_1}$	$b_2 \pm s_{b_2}$
Clinical mastitis	7.5	2.91 ± 0.72^a	-0.20 ± 0.080^b
Bacterial infection	5.0	1.55 ± 0.24^a	-0.08 ± 0.026^a
Leucocyte count	5.356	0.25 ± 0.03^a	-0.02 ± 0.003^a

[a] Significant at the 0.01 level of probability.
[b] Significant at the 0.05 level of probability.

accordance with the findings in Table 1, age adjustments were performed on all three scores to correct for both linear and curvilinear regression. Age-adjusted scores were expressed to the same degree of accuracy as original scores, i.e., as integers for clinical mastitis and bacterial infection and as three-place logarithms for leucocyte score. All analyses performed were based upon the age-adjusted scores, with the exception of analyses involving hock and udder measurements. In the latter case, age differences were removed by the analysis of variance.

RESULTS AND DISCUSSION

Heritability and repeatability. Estimates for the heritability of clinical mastitis were obtained from the within herd, breed, and year correlation between paternal sisters, and from the intra-herd, intra-breed regression of daughter on dam. The analysis of variance for the intra-class correlation appears in Table 2, the regression analysis in Table 3.

The estimate of heritability from the paternal sister analysis (Table 2) was $.79 \pm .21$. The estimate from the regression of daughter on dam (Table 3) was $.06 \pm .18$. Although the .95 confidence intervals for these two estimates overlap in the neighborhood of .40, the divergence between the estimates is extreme.

Repeatability was obtained by modifying the intra-class correlation analysis to the form of Table 4. Repeatability of score for clinical mastitis was estimated at $.31 \pm .06$. The .95 confidence interval for this estimate is .19 to .43. Repeatability is that fraction of the total phenotypic variance due to both additive and nonadditive genetic variation plus variation due to permanent environ-

TABLE 2

Analysis of variance for clinical mastitis between paternal sisters

Source of variation	d. f.	M. S.	E (M. S.)	Variance components
Total	681	146.3		
Between herd-breed-year classes	28	502.5		
Between sires in H-B-Y classes	314	157.1	$E^a + 1.902\ S^b$	26.5
Within sires in H-B-Y classes	339	106.8	E^a	106.8

[a] E is variance between paternal sisters.
[b] S is additional variance between sets of paternal sisters.
Heritability = $4S/S+E = 0.79 \pm 0.21$.

TABLE 3

Covariance analysis for clinical mastitis to determine regression of daughter (Y) on dam (X)

Source of variation	d. f.	X^{2a}	XY	Y^{2a}	Regression Y on X
Total	119	16,925	2,621	13,808	
Between herd-breed classes	7	5,178	2,248	2,794	
Within H-B classes	112	11,747	373	11,014	0.03 ± 0.09

[a] X^2 and Y^2 have been corrected for the use of averages in the computations.
Heritability (0.06 ± 0.18) is computed as twice the regression of Y on X.

mental influences. Hereditability is that fraction of the total phenotypic variance due to the additively genetic variance. For this reason, repeatability is expected to be higher than heritability, and generally may be regarded as an upper limit on heritability. The heritability estimate of .79 from the paternal sister correlation is, therefore, inconsistent with the value of .31 obtained for repeatability.

The source of this discrepancy was investigated by partitioning the "between cows in herd-breed classes" source of variation in Table 4 into two parts, namely, "between sires in herd-breed classes" and "between cows in sires." By this procedure, the variance component (C) of Table 4 was separated into two components, (S) and (D). The first of these components, (S), represents the variance between groups of daughters within a herd-breed class sired by different bulls, and is expected to contain one-quarter of the additively genetic

TABLE 4

Analysis of variance of clinical mastitis for repeatability

Source of variation	d. f.	M. S.	E (M.S.)	Variance components
Total	681	146.3		
Between herd-breed classes	9	1231.1		
Between cows in H-B classes	412	157.4	$E^a + 1.615\ C^b$	41.1
Between lactations of the same cow	260	91.1	E^a	91.1

[a] E is variance between lactations of the same cow.
[b] C is additional variance between cows in the same herd and of the same breed.
Repeatability = $C/C+E = 0.31 \pm 0.06$.

variance and a portion of the epistatic variance. The component (D) represents the variance between daughters of the same sire, and is expected to contain three-quarters of the additively genetic variance plus a major portion of the epistatic variance and all the dominance variance. For this reason (D) is expected to be at least three times as large as (S). However, in the present case, the results obtained were as follows:

$$S = 29.3 \pm 13.6$$
$$D = 13.9 \pm 10.4$$

Thus, the heritability estimate from the paternal sister correlation, which is based on the component (S), is of questionable value, owing to the apparently inflated value of (S). No reasonable explanation, other than sampling error, can be advanced for this disagreement with expectation.

Heritability and repeatability estimates were obtained in a like manner for bacterial score and leucocyte score. These estimates, along with those for clinical mastitis, are presented in Table 5. The estimated variance components from the paternal sister correlation for bacterial score had the same unrealistic relationship as that described for clinical mastitis.

Relationship of clinical mastitis to laboratory criteria. Phenotypic and genetic correlations between all pairs of the three scores were computed, and are presented in Table 6. Genetic correlations were obtained separately from the two analyses, as the genetic covariance estimates from the two sources were widely divergent in some cases. However, the correlations obtained were in reasonable agreement in most cases, the exception being the genetic correlation

TABLE 5

Heritability and repeatability estimates for clinical mastitis, bacterial infection, and leucocyte count

Score	Heritability		Repeatability
	Daughter-dam regression	Paternal sister correlation	Intra-cow correlation
Clinical mastitis	0.06 ± 0.18	0.79 ± 0.21	0.31 ± 0.06
Bacterial infection	0.18 ± 0.14	0.87 ± 0.21	0.24 ± 0.06
Leucocyte count	0.38 ± 0.20	0.23 ± 0.22	0.42 ± 0.05

TABLE 6

Phenotypic and genetic correlations between scores for clinical mastitis (X_1), bacterial infection (X_2), and leucocyte count (X_3)

Scores	Phenotypic	Genetic	
	Paternal sisters within H-B-Y classes	Paternal sisters within H-B-Y classes	Daughter-dam within H-B classes
X_1X_2	0.23 ± 0.05	0.29	0.23
X_1X_3	0.45 ± 0.05	0.80	0.98[a]
X_2X_3	0.47 ± 0.05	1.23	0.24

[a] Approximate standard errors computed after Reeve (7) suggest statistical significance for this value.

between scores for bacterial infection and for leucocyte count. The correlation of 1.23 for this relationship is outside the realm of possible values.

Estimates of the genetic correlation between clinical mastitis and leucocyte score were .80 and .98. These estimates suggest that many of the genes which influence clinical mastitis also influence leucocyte count. If this is the case, then selection for low leucocyte count should automatically result in selection for low clinical score, i.e., greater resistance to clinical mastitis. The reverse also is true.

All other correlations, with the exception of the impossible value, were greater than .20 and less than .50. The phenotypic and genetic correlations between clinical mastitis and score for bacterial infection were quite uniform, all falling between .20 and .30. Correlations of this magnitude suggest that the two traits are determined to only a minor degree by similar genetic factors. Thus, this correlation suggests that selection for a low score for bacterial infection would be a relatively ineffective means of decreasing the score for clinical mastitis.

In order to investigate further the usefulness of laboratory criteria in selection for resistance to mastitis, selection indexes were computed by applying the methodology of Smith (8) and Hazel (4). The objective of calculating selection indexes was to determine the extent to which the inclusion of laboratory scores in the selection criteria might be expected to enhance genetic progress in selection for resistance to clinical mastitis. Six indexes, three from the paternal sister data and three from the daughter-dam data, were computed. Indexes were computed where all three variables were included in the index, and where each of the two laboratory criteria were included separately with clinical mastitis. None of the indexes calculated from the paternal sister data gave evidence of advantage from the use of laboratory methods. This was probably due in part to the high heritability estimate for clinical mastitis obtained from this analysis. When heritability is high for the trait in which improvement is sought, there is less opportunity for an index to increase relative efficiency. Indexes computed from the daughter-dam data which included the leucocyte score showed an expected increase in efficiency of 140% over the use of clinical mastitis alone; whereas, the index involving only clinical mastitis and bacteria score still showed no advantage over the use of clinical mastitis alone. These results suggest that the leucocyte score as defined and applied in this study may be valuable as a selection aid for resistance to clinical mastitis. The score for bacterial infection appears to be of little or no value from this standpoint.

Relation between udder height and mastitis. Correlations were obtained between udder height, hock height, udder height minus hock height, and the three scores relating to mastitis. Hock and udder measurements were available for 619 of the 682 lactations. The data used for calculating these correlations were not adjusted for age differences, as it was desired to calculate correlations with and without age (lactation number) effects removed. All analyses concerning hock and udder measurements were conducted on a between-cow basis. These correlations are given in Table 7. The upper figure of each pair in

Table 7 is the correlation within herd-breed classes; whereas, the lower figure is the correlation within lactation number, within herd-breed classes. The upper figure can be regarded as equivalent to the correlation within a herd of a single breed but with cows varying in numbers of lactations; whereas, the lower figure represents a comparison between cows all having the same number of lactations.

All correlations involving udder height and udder height minus hock height were negative and significantly so, usually at the .01 level. This means that as udder height decreases the mastitis scores increase. None of the correlations involving hock height were significant, i.e., there is no discernible association between hock height and mastitis. The correlations involving udder height minus hock height are essentially the same as those involving udder height. The reason for calculating udder height minus hock height was that udder pendulousness is more often associated with the position of the udder relative to the hock than to the barn floor. However, from the results obtained it is apparent that as far as the incidence of mastitis is concerned, it makes little difference whether udder height is measured from the barn floor or from the point of the hock. Two reasons for this were revealed by the data collected in this study. In the first place, hock height possesses a rather low degree of variability, the standard deviation in hock height being only 0.8 in. where the comparison is within herd-breed classes. Secondly, the correlation between udder height and hock height is not as high as might be expected. This correlation was .23 within herd-breed classes and .28 where the analysis was within age groups within these classes. Although these correlations are both highly significant, they are not large enough for hock height to be considered a major factor in determining variation in udder height.

The foregoing results provide direct evidence that between-cow differences in susceptibility to mastitis are associated with differences in udder height, the more susceptible cows being those with the more pendulous udders. Where age differences were not removed, the correlations were of sufficient magnitude to account for sizable portions of the variation in scores associated with mastitis.

TABLE 7

Correlations between udder height measurements and three scores associated with resistance to mastitis

Score	Udder measurement		
	Udder height	Hock height	Udder height—hock height
Clinical mastitis	−0.28[a]	−0.01	−0.29
	−0.13	−0.02	−0.11
Bacterial infection	−0.38	0.00	−0.39
	−0.11	0.04	−0.13
Leucocyte count	−0.48	0.00	−0.49
	−0.12	0.02	−0.15

[a] Upper member of each pair is the correlation for cows of the same breed and herd. Lower member is the correlation for cows in milk the same number of lactations and of the same herd and breed.

Correlations $\geqslant 0.12$ significant at .01 level of probability.
Correlations $\geqslant 0.08$ significant at .05 level of probability.

This was especially true for the leucocyte count, where udder height accounted for 23 to 24% of the variation in this score. Even with age differences removed, all correlations were significant, but were reduced to the range of −.11 to −.15 and under these circumstances accounted for only about 1 or 2% of the variance in the scores for clinical mastitis, bacterial infection, and leucocyte count.

General discussion. The results presented do not provide conclusive evidence for the probable effectiveness of selection for resistance to mastitis. The heritability estimate from the daughter-dam analysis was not significantly different from zero; whereas, the statistically significant estimate of heritability from the paternal sister analysis must be viewed with caution, due to the unrealistic relationship between the variance components. A repeatability estimate of .31 ± .06 was obtained, which can be interpreted as indicating that if resistance to mastitis is inherited, it is unlikely that its heritability is greater than .43. Therefore, the .95 confidence limits on heritability estimated from this investigation might be considered as ranging from .00 to .43. The .95 confidence limits of Lush (6) and Legates and Grinnells (5) were .06 to .70 and .07 to .47, respectively. The limits from the three studies are not widely divergent, especially considering differences in scoring for mastitis.

Whether it would be desirable to include mastitis resistance in a dairy cattle breeding program depends on the relationship between mastitis resistance and milk production, as well as the heritability of mastitis resistance. The best information available concerning this relationship is that provided by Dodd and co-workers (2, 3), who have shown that cows which milk rapidly have higher lactational milk yields and, in addition, that cows milking rapidly have a higher incidence of clinical mastitis and bacterial infection. If this negative relationship indicated between milk production and mastitis resistance is substantiated, then it is likely that methods to decrease mastitis incidence must be confined largely to ones of a nongenetic nature. However, if the correlation between milk production and mastitis resistance is negative but small, or zero, or positive, then it might be feasible to include mastitis resistance in the selection criteria if its heritability were .20 to .30, which seems to be about the value indicated by results presently available.

A valid criticism of the work reported here is that mastitis was not defined in a wholly satisfactory manner. Much of the current research with mastitis is based on laboratory tests rather than clinical histories. White *et al.* (9) and Crossman *et al.* (1) have shown that bacterial infection without clinical symptoms may decrease milk yield. However, the findings of Crossman *et al.* (1) further indicate that clinical mastitis has a more pronounced effect upon yield than do infections which fail to become clinical. Hence, it seems more appropriate to breed for resistance to clinical mastitis than for resistance to bacterial infection. An alternative would have been to define mastitis in such a way as to include both clinical and laboratory data in the definition. This was our original intention; however, the weights given to each factor would have been largely arbitrary, and subject to even greater criticism. Under the circumstances, the system used herein was taken to be the least objectionable of the alternatives.

If, in fact, bacterial infection does have a sizable influence on milk yield, then the problem of mastitis control is relevant to the animal breeder in another respect. In this case, the inherent capacity for milk production could probably be measured most accurately during the first lactation before udder infection is of much consequence. In addition, if mastitis resistance and milk production are negatively correlated genetically, as suggested by the work of Dodd and co-workers (2, 3), then the genetically superior individuals, production-wise, are operating under a handicap in later lactations when the incidence of mastitis is higher. Under these circumstances, selection based on first-lactation records would be largely for milk production; whereas, selection based on subsequent records would include some selection for resistance to mastitis and udder infection.

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RATES OF IMPROVEMENT BY PROGENY TESTING IN DAIRY HERDS OF VARIOUS SIZES[1]

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SUMMARY

Rates of genetic gain in milk production by progeny testing were examined, using characteristics of Michigan Holsteins. The production records from 34,073 Holsteins on DHIA test averaged 12,237 lb. of milk and 435 lb. of fat (305-2×-ME). AI daughters numbered 5,098 from 187 bulls and averaged 12,305 lb. of milk and 444 lb. of fat. Characteristics found were: repeatability, .46 for milk, .40 for fat; heritabilities from correlations between AI paternal sisters, .31 for milk, .23 for fat; regression of future AI daughters on first n tested AI daughters, $\frac{n}{n+12}$ for milk and $\frac{n}{n+16}$ for fat; average age at calving 4.4 yr.; cows removed annually, 26.3%, one-tenth involuntarily in each of the first four lactations and one-fourth in later lactations; and heifers born which come into production, 70%.

In herds of less than 100 cows, progeny testing was less efficient in improving the expected rate of genetic gain than the use of young sires selected on the basis of their dams' production. In herds of 100 and 200 cows, progeny testing had a slight advantage over the latter method.

Progeny testing in AI populations of 10,000 tested cows gave possibilities of annual genetic progress of from 1.7 to 2.3% of the average annual yield, depending upon the number of sires sampled and the proportion of those sampled which are selected for service. Further improvement seems possible if the percentage of cows on test were increased and if more efficient use were made of the tested bulls in AI service.

The progeny test can be the most accurate source of information about a dairy sire's breeding value. However, progeny testing increases the generation interval and may actually decrease genetic gain per year (8). When young sires are bred to enough cows to progeny-test them adequately, there may be few cows left to breed to the tested bulls approved for heavy service (30). Since the number of bulls that can be tested in herds of conventional size is small, the subsequent intensity of selection is limited.

Ways to overcome the disadvantages and to utilize the progeny test to appraise sires destined for use by artificial insemination have been developed (16, 18, 30). Optimum use of progeny testing by artificial insemination could result in annual improvement twice that possible in individual herds (27). Most estimates have indicated that the annual improvement in genetic merit of individual dairy herds does not exceed 1% of the mean annual yield (8, 9, 17, 22, 26, 27).

Use of the progeny test requires testing bulls as young as possible. Information from New York, Oregon, and New Zealand (1, 24, 25) suggests that AI daughters of young sires selected on the basis of pedigree produce as well as the

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AI progeny of older bulls selected on their natural proofs. Improvement should result when the pedigree-selected young sires are tested in AI and the best retained for extensive use.

Young bulls sampled should be from the best progeny-tested sires mated to outstanding females. Under such plans, AI units could play a constructive role in dairy cattle breeding, rather than having their rate of genetic progress tied to that of herds now producing bulls (29).

Information needed to measure genetic gain and to formulate progeny tests has often been based on scanty evidence. Michigan DHIA records have made larger amounts of data available for analysis. This study proposed to examine characteristics of the tested Holstein population of Michigan and with these to compare genetic improvement possible with progeny testing in populations of various sizes.

SOURCE OF DATA

Production records used were 65,392 DHIA records from 34,073 Holstein cows in Michigan. All records were completed records from 180 to 305 days in length and were adjusted to twice-a-day milking and mature equivalent by standard DHIA factors. The average of all records was 12,237 lb. of milk and 435 lb. of fat. Of these records, 18,327 collected by central processing at Michigan State University since October, 1954, were the source of information about the nongenetic characteristics of Michigan Holsteins.

PREVIOUS SELECTION OF AI SIRES

Nearly all sires purchased by AI units during the period under study were proved in natural service (NS). The average production for the daughters of these sires is given in Table 1.

The AI purebred and grade offspring totaled 5,098 daughters with 12,305 lb. of milk and 444 lb. of fat. The daughters of AI sires averaged 80 lb. of milk and 11 lb. of fat more than the non-AI population. However, 40% of the AI progeny completed their only records from 1953 to 1955. From 1945 to 1955, Holstein herds on DHIA test in Michigan increased 34 lb. of fat per cow. The average increase per year was approximately 0.9% of the average annual yield. Since the upward trend in the annual average probably reflects important contributions from improved feeding and management, some of the apparent

TABLE 1
Average production of daughters of AI sires

	No. sires	No. daughters	No. records	Milk	Per cent	Fat
Purebred daughters						
NS	129	1,917	4,369	13,334	3.64	486
AI	139	2,678	4,938	12,537	3.60	451
Grade daughters						
NS	62	267	485	12,357	3.60	445
AI	117	2,420	3,753	12,049	3.63	437

superiority of AI progeny likely is due to changes in these. Such a conclusion is supported by the negligible differences in production between AI progeny and their naturally sired contemporaries in Michigan herds [Wadell and McGilliard (35)]. The evidence suggests the sires used in AI in Michigan have not increased substantially the genetic level of production of tested Michigan Holsteins above the level attained by NS. Similar conclusions were reached on other dairy populations by Hahn *et al.* (11) and Robertson and Rendel (31).

Most sires used in AI in Michigan were selected on their first available natural proofs, usually about five daughters. The relationships between the first natural proofs and the subsequent AI daughter averages for 98 Holstein bulls are shown in Table 2. Also the daughter average of the natural proof is compared with the daughter-dam difference.

TABLE 2

Relationships between first natural proofs and AI daughter averages

Method	No. daughters	Milk	Fat	Milk		Fat	
				r	b	r	b
Daughter average	5,005 (AI)	12,260	445				
Daughter average of NS proof	963 (NS)	13,800	501	.37	.18	.30	.16
Difference between Daughter av.–Dam av.	795 (NS)	1,090[a]	56[a]	.35	.18	.33	.19

[a] Average amount daughters exceeded their dams.

The average of all natural daughters was more closely correlated with subsequent AI performance, .43 for milk and .39 for fat, than was the first proof. The difference is not large enough to make much delay in selection useful. Recent work (15, 18, 32, 34) has shown that the first AI proof (with a number of daughters comparable to what would be expected in NS proofs) is superior to the NS proof for estimating the production of future AI daughters.

Bulls can be chosen for AI as accurately on the basis of their simple daughter average as by the use of the conventional dam and daughter proof. Legates (18) indicated that only one-half of all AI progeny have dams with production records. Limiting the estimate of a sire's breeding value to the information available from dam and daughter pairs wastes considerable data.

GENETIC PARAMETERS TO ESTIMATE GENETIC GAIN

Repeatability. Intra-herd repeatability was calculated from the 18,327 centrally processed DHIA records by components of variance as outlined by Henderson's Method I (13). The analysis is shown in Table 3.

The repeatability of milk and fat within herd and year is $\frac{C}{C+E}$, where C is the variation between cows in the same herd and E is the unanalyzed portion of the variance. Repeatabilities were .46 for milk and .40 for fat. Herd accounted for approximately one-third of the total variation among lactation records. These estimates agree well with other published data.

TABLE 3

Components of variance for milk and fat production

Component	d.f.	Variance		Fraction of total	
		Milk[a]	Fat[b]	Milk	Fat
Herds	839	246	34	.34	.36
Years	2	3	0	.00	.00
Herds × years	754	29	4	.04	.04
Cows within herds	13,772	202	22	.28	.24
Residual	2,959	238	33	.33	.35
Total	18,326	718	94		

[a] Milk coded in 100 lb.
[b] Fat coded in 10 lb.

Heritability. Beal (3), using the intra-sire regression of daughters on dams, measured the heritability of milk and fat production from these data to be .264 ± .016 for milk and .262 ± .018 for fat production. Commonly accepted values for heritability range from .20 to .30.

Paternal-sister correlations. Three estimates of the correlations between paternal sisters were made from various portions of the data. The first estimate utilized the 51,656 records of 26,700 naturally sired cows. A paternal-sister correlation of .16 was obtained for both milk and fat. Multiplying by four yields a heritability of .64. It is likely that an environmental correlation between paternal sisters in the same herd is inflating the correlation between sisters.

Correlations between paternal sisters of .05 for milk and .03 for fat were obtained in an analysis of 5,098 AI progeny with 8,691 records. However, 7% of the total variation was found to be interaction between herds and sires. These records were collected over 10 yr. and were subject to the selection of records characteristic of standard DHIA programs. Wadell and McGilliard (35) found no interaction in records collected through central processing; however, their measure of production was the difference between first lactations of AI and non-AI daughters in the same herd. No interaction has been found by others (19, 21).

To reduce the effects of time and of selection of records, records of 2,631 AI daughters tested under central processing were analyzed in the individual years in which the records were begun. The herd-sire interaction was generally negligible for the individual years. Recombining the analysis with the interaction not separated by years produced Table 4. The data were too few to pursue the point, but years seem to be involved in the positive herd-sire interaction.

Predicting production of future AI daughters. The regressions of future daughters on n tested daughters, each daughter in a different herd, estimated from components of variance in Table 4 are $\frac{n}{n+11.9}$ for milk and $\frac{n}{n+16.4}$ for fat.

The components from Table 4 are nearly in agreement with other published data (6, 19, 30). Multiplying by four the paternal-sister correlations for the AI data suggests heritabilities of .31 for milk and .23 for fat.

TABLE 4
Variances of milk and fat for AI paternal sisters

Component	d.f.	Variance		Fraction of total	
		Milk[a]	Fat[b]	Milk	Fat
Herds	350	244	33	.36	.38
Sires	242	52	5	.08	.06
Years	2	5	1	.01	.01
Herds × sires	1,134	61	8	.09	.09
Residual	902	309	40	.46	.46
Total	2,630	671	87		

[a] Milk coded in 100 lb.
[b] Fat coded in 10 lb.

Means and standard deviations. Table 5 summarizes the means and phenotypic standard deviations for milk and fat from three portions of the data. These values are similar to others found in the literature and agree particularly well with those presented by Henderson and Carter (15). With phenotypic standard deviations of approximately 2,600 lb. of milk and 90 lb. of fat, and heritability of about .25, the genetic standard deviations are 1,300 lb. of milk and 45 lb. of fat.

TABLE 5
Means and standard deviations of milk and fat

Population	No. cows	No. Records	Mean		Standard deviation	
			Milk	Fat	Milk	Fat
Naturally sired cows	26,700	51,656	12,095	425	2,546	92
All AI progeny	5,098	8,691	12,255	440	2,440	88
AI progeny with centrally processed records	2,058	2,631	12,330	445	2,590	93

NONGENETIC PARAMETERS

Genetic gain depends on the generation interval, the number of available replacements, and the culling practices followed. Central processing of DHIA records provided an opportunity to survey a large number of records for information relative to these factors.

Generation interval. The generation interval for females was defined as the average age at calving of the tested population in a given year. Age at calving was reported for 17,662 lactation records and averaged 4.4 yr. Similar estimates were reported by Rendel and Robertson (27) for Shorthorns and Friesians in England. Lush (20) estimated the mean generation interval in dairy cattle to be 4 to 4.5 yr.

Generation intervals for dams of sires, sires of females, and sires of future sires could not be estimated from the data. The generation interval for dams of herd sires would be at least as long as that for females and possibly longer if bulls were not kept from first calvings. This interval was set at 5.0 yr. Since all future bulls are to be sired by tested bulls, the interval for sires of future sires was taken to be 7.0 yr. The average age of sires of females will vary with the per cent of cows bred to young sires, from 2.0 yr. for young sires to 7.0 for tested sires. The

interval decreases 0.5 yr. from 7.0 for each 10% increase in number of cows bred to young sires.

Cows removed annually. The causes of removal and the percentage of cows removed annually were considered since the more cows lost involuntarily the less freedom the dairyman has to cull individual animals on their productive ability.

Losses from 269 Holstein herds continuously on test under the central processing system were tabulated to estimate the number of cows removed each year. The herds averaged 27.3 cows in size and appeared representative of the population under study. Annual removals for all reasons averaged 26.3% of the cows. The figure is bracketed by the reports of Seath (33) and Asdell (2).

Table 6 gives the distribution by reasons for disposal.

TABLE 6

Reasons for cow removals in 269 Holstein herds

Reason	1954-55*	1955-56	1956-57	Mean
	(% cows removed)			
Dairy purposes	15.1	15.4	16.8	15.6
Low production	35.4	36.2	39.1	36.6
Physical injury	10.0	9.8	11.2	10.2
Mastitis	8.2	6.7	7.3	7.4
Brucellosis	3.1	2.5	2.2	2.7
Tuberculosis	3.5	4.0	1.8	3.3
Hard-milker	2.8	2.6	2.0	2.5
Sterility (all forms)	16.0	16.4	14.0	15.7
Death	5.9	6.4	5.7	6.0

* 205 herds.

Cow removals by lactation. Information on the number of cows removed with each additional lactation is needed for calculating involuntary culling losses by the method of Rendel and Robertson (27). Table 7 presents data from 11,416 Michigan Holstein records plus comparable information from reports by Seath (33), Asdell (2), and Rendel *et al.* (28).

Seath's and Asdell's reports were computed on a yearly basis, whereas those from the present study and Rendel's were figured on a lactation basis. The two systems could be considered equivalent if it is assumed that cows 2 to 3 yr. of age are in their first lactation, those 3 to 4 yr. of age are in their second lactation, etc.

The values in Table 7 include all cows culled from the herd, regardless of the reason for removal. A distinction should be made between those cows removed from the herd for voluntary reasons, i.e., the herd-owner decides to cull the cow because of low production, difficulty in milking, etc., as opposed to cows lost involuntarily. Although about one cow in six is sold for dairy purposes, many are sold to nontesting herds; whereas, others will not be satisfactory producers and will be resold for beef. It was assumed that all cows removed from the herds did not re-enter the tested population.

Cows sold because of disease, mastitis, and sterility, and animals lost because of injury or death were considered cases of involuntary culling. Table 8 presents

TABLE 7
Per cent of survivors of previous cullings removed each lactation

Age	Lactation	Present study	Rendel *et al.*	Seath		Asdell	
				Iowa	Kansas	Kansas	N.Y.
2	1	25.2	27.7	28.1	31.6	12.6	6.0
3	2	27.2	35.4	31.3	30.4	15.5	17.2
4	3	26.2	35.2	23.2	27.2	23.1	26.4
5	4	28.5	32.2	25.0	26.8	29.2	35.0
6	5	31.9	36.7	27.4	26.1	30.1	34.0
7	6	36.0	49.4	26.3	29.6	21.6	35.2
8	7	40.9	47.1	31.8	32.9	18.6	36.5
9	8	54.2	50.6	34.2	42.2	14.3	.....
10	9	49.5	74.3	38.4	44.4	.....	.....

the ratios of animals removed for voluntary and involuntary reasons by lactation number. Data reported by Asdell (2) for Kansas and New York herds showed a similar trend.

TABLE 8
Changes in per cent of voluntary and involuntary removals with increasing number of lactations

Lactation No....	1	2	3	4	5	6	7	8	9
Voluntary	18.6	18.4	16.3	15.5	16.1	14.8	19.2	23.2	23.4
Involuntary	6.6	8.9	10.0	13.0	15.8	21.2	21.7	31.0	26.1

Rendel and Robertson (27) assumed one-sixth for the natural mortality of dairy cows for the first three lactations, and one-third for all subsequent lactations. The information from Michigan could be most easily summarized by losses of one-tenth for the first four lactations and one-fourth thereafter.

Number of herd replacements. There is little evidence from commercial herds as to the mortality of females from birth until first calving. The identification numbers of all calves born during 1954 in the 269 herds used previously were checked against the numbers of the first-calf heifers entering the same herds in 1956 and 1957. Thirty-six per cent of the female calves born in 1954 were identified as first-calvers.

An adjustment was necessary, for not all of the heifers would have been expected to calve by the date on which the survey was made. The adjustment was based on the actual distribution of the age at first calving for 5,055 first lactation records found in the centrally processed records. The adjusted value indicated that 47% of the heifer calves checked would eventually enter the same herd. This is similar to information from the New Zealand Dairy Board (24). However, a check of 184 first-calvers entering the herds under study during a 5-wk. period revealed that for every two heifers reported correctly a third was incorrectly identified. Increasing the original estimate (47%) by one-half would give a final estimate of 70% of all females born that ultimately enter the milking herd. Studies on several experiment station herds by Frick and Henry (10) showed that from 66 to 83% of all females born entered the milking herd. Rendel and Robertson (27) implied that 70 to 80% of all heifer calves born will calve in the same herd. It seems best to assume that 70% of all heifer calves born are available as herd replacements.

Bull replacements. Estimates needed that affect the male portion of the population involve the number of tested bulls required, the expected life-span of sires used in artificial insemination, and the percentage of young sires that survive the waiting period after sampling.

Bratton *et al.* (5) reported that it is possible to obtain from 25,000 to 50,000 progeny per sire per year at reasonable levels of fertility, using only 50% of the semen produced. Figures for 1957 (23) showed that the average annual number of cows bred per sire was in the neighborhood of 2,250 cows. Figures were not given for individual breeds, but it is unlikely that any stud is currently breeding an average of 10,000 cows per sire for any breed.

The service life of tested bulls in AI is usually assumed to be 3 yr. (18, 27). Becker and Arnold (4) reported slightly less service life per sire at 2.87 yr. Ninety-one Holstein sires in service at one of the studs servicing Michigan had an average tenure in stud of 3.05 yr. Thus, 3 yr. of service life per sire seems an adequate estimate.

No specific data are available on the survival percentage for young sires in waiting after sampling. Eighty per cent is the usual figure assumed (7, 18, 30).

RATES OF IMPROVEMENT

Genetic gain without progeny testing. Rendel and Robertson (27) reported a method for calculating genetic gain in the individual herd. In estimating genetic gain in a 100-cow herd, Rendel and Robertson's procedure assumed that no progeny testing was done and that all replacements, both male and female, were bred from the herd. Without progeny testing there is no gain from selecting bulls to sire the next generation. Therefore, only the improvement due to selecting female parents needs to be calculated. The authors cited Lush (20) in assuming that males intended for breeding purposes would be saved from the top 5% of the milking herd.

The increased amount of voluntary culling possible with Michigan data did not result in any additional annual gain in genetic merit. If 70 to 80% of the heifers born entered the milking herd, the estimate of genetic gain was 1% of the mean annual yield. The gain that can be obtained by selecting dams of herd sires over-shadows the contribution made by selecting cows to produce future female replacements. It was pointed out by Rendel and Robertson (27) that nearly all herds bring in new sires whose breeding value is less well-known than if they were home-bred and, consequently, the rate of genetic improvement is reduced.

Genetic gain with progeny testing. Rates of improvement expected from progeny testing are shown in Figure 1 for herds of 25, 50, 100, 200, and 10,000 cows. A reference line marks the level of genetic improvement expected annually from selection of the female parents of the replacement males and females without progeny testing. It was assumed that currently used techniques would allow a single tested sire to breed all females in a herd that would not be needed for testing more young sires. Varying numbers of sires were sampled. The percentage of the cows bred to young sires was also varied.

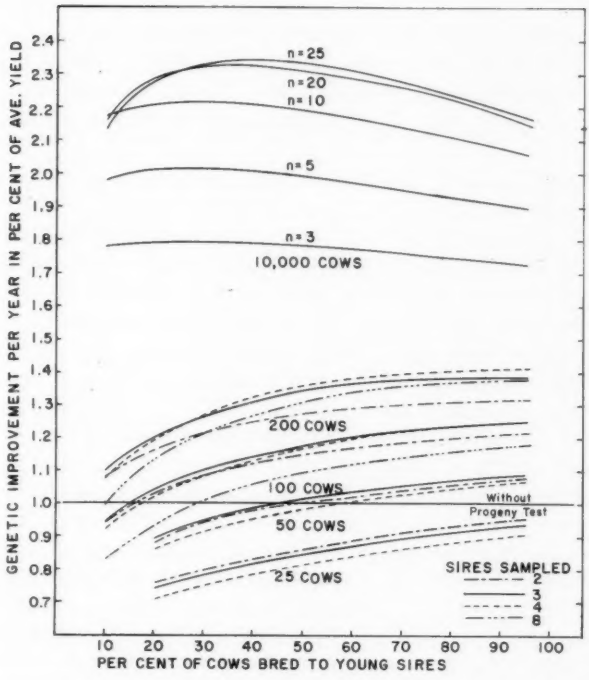

FIG. 1. Genetic improvement with progeny testing in herds of various sizes, saving one of n sires sampled.

Twenty-five cow herd. Progress with progeny testing is largest when nearly all of the herd is bred to two young sires and the better one is saved for future use. However, all points on the graph fall below the level of improvement which can be expected without progeny testing. The dairyman has the alternatives of (1) saving sons of his best producing cow(s) and using them for short periods of time to keep the generation interval short, or (2) utilizing such discretion as he can in picking AI sires to breed his cows.

Fifty-cow herd. A similar situation exists for the 50-cow herd, although the calculated gain from progeny testing exceeds the reference level when at least 60% of the cows are bred to young sires. Sampling three young bulls and saving the best one shows a slight advantage over sampling two or four young sires. The additional gain derived from progeny testing is small, and it is doubtful that it is worth the labor and expense involved in keeping an older sire to breed the remaining cows. Therefore, the suggestions made for the 25-cow herd would apply as well to the 50 cows.

One hundred–cow herd. The 100-cow herd could exist as an individual unit or as several smaller herds desiring to follow the same breeding program. Progress from progeny testing exceeds that expected from the alternative method by as

much as 20% when 60% or more of the females are mated to young sires and one tested sire is selected from those sampled. If several small herds are involved, the number of bulls sampled might depend upon the number of herds desiring to breed their cows naturally. Factors other than the absolute annual gain may influence the breeding plan, since the additional gain from progeny testing is slight.

Two hundred–cow herd. In a herd of 200 cows, nearly all values for progeny testing are above the 1% reference point. The few that are not involve testing more bulls than is economically feasible. Peak progress is realized when four young sires are sampled, and one is saved for future service. Sampling three young sires is almost as fruitful as sampling four, and factors other than the absolute annual gain may decide the number to be sampled. In either case, genetic progress is from one-fourth to one-third above that expected without progeny testing. Dairymen concerned with cow populations of this size should consider the use of progeny testing, unless they are satisfied that the AI units can do as well in improving the producing ability of the herd.

AI populations. The curves at the top of Figure 1 illustrate the maximum progress possible under the proposed plan for an AI population of 10,000 tested cows. A single tested sire is assumed capable of breeding all cows not needed for testing young bulls. If many bulls are tested, peak efficiency results when 30 to 50% of the population are bred to young sires. At the more practical levels of sire sampling, Figure 1 substantiates the estimates of Legates (18) and Henderson (14) for the percentage of the population that needs to be mated to young sires for maximum genetic improvement.

The example shows a definite advantage for progeny testing. If studs could be persuaded to undertake such a scheme, even at the lowest level of sampling, most herds could well afford to put their bull breeding problems in the hands of the stud and dismiss the notion of progeny-testing sires for their own use.

The estimate does not approach the actual situation, since complete recording of production data is specified and, in reality, the bulk of the cows bred to AI bulls are untested. Most states have from 5 to 15% of their dairy cattle enrolled in a production-testing program. Only this portion of the population is available for testing young sires; yet AI units must keep sufficient bulls to breed the unrecorded cows, as well. Consequently, more than a single tested sire would be required for most breeds in large studs.

Table 9 represents the progress thought possible for a practical situation. It is assumed that the stud is breeding 150,000 cows of a single breed annually. About 7% of all cows in Michigan are in the DHIA testing program, and there is evidence that the percentage is no higher for herds utilizing artificial insemination. Therefore, the effective population is 10,000 cows, but sufficient sires must be kept to breed all 150,000 cows. The need for additional sires to breed the untested cows reduces the intensity of selection and accounts for the difference in the expected genetic gain in Figure 1 and Table 9 with the same values of n. If each bull can settle as many as 10,000 cows per year, a minimum of 15

TABLE 9

Annual genetic improvement in per cent of average yield for AI population of 150,000 cows, 10,000 tested, where five sires saved from n tested

Bred to young sires	n					
	15	20	25	50	100	125
(%)						
10	1.55	1.59	1.61	1.55	1.43	1.40
20	1.63	1.69	1.73	1.74	1.62	1.60
30	1.66	1.73	1.78	1.82	1.76	1.72
40	1.66	1.74	1.80	1.86	1.80	1.76
50	1.65	1.74	1.79	1.87	1.83	1.80
60	1.65	1.74	1.78	1.87	1.84	1.83
70	1.65	1.73	1.78	1.87	1.86	1.83
80	1.63	1.70	1.75	1.84	1.84	1.81
90	1.62	1.69	1.73	1.82	1.82	1.79
95	1.61	1.68	1.73	1.80	1.81	1.79

tested sires is needed. If the service life of an AI sire is 3 yr., an average of five bulls must be replaced each year.

Values obtained were appreciably below those estimated for the optimum situation (Figure 1) when a large number of bulls is sampled. However, when one of three bulls sampled is saved, the difference in gain between Figure 1 and Table 9 is only 0.13 % of the mean annual yield.

The procedure for maximum gain in the practical example is to breed 50-70% of the cows to young sires and to sample ten young bulls for each one saved for heavy service. Such a procedure would yield an average of 30 tested daughters per bull. If five bulls are needed each year, the stud would need to sample 50 young sires. Thus, the plan for maximum progress may not be economically practical.

Sampling a larger number of young sires per bull saved gives slightly less progress. The question is of balancing the testing of fewer bulls against the additional gain expected when 50 are tested. Testing three to five young bulls for each one saved is less than optimum, but is closer to being possible in practice.

If five are sampled for each one saved, the optimum gain occurs when 40% of the cows are bred to young sires. The point shifts to 30% when three are sampled for each one saved. The latter situation is the most realistic compromise between economy and genetic gain and yields a maximum rate of improvement only 0.2% of the mean annual yield below that possible when ten young sires are sampled for each one saved.

Even if the bull-sampling ratio were reduced to three to one, the annual increase in genetic merit expected for the population would equal approximately 1.6%, or about 175 lb. of milk and 6 lb. of fat per year. Estimates of progress from actual herds fall short of this amount, except for the report by Harvey (12).

Two additional possibilities would improve the rate of genetic gain postulated for the population under study. First, increasing the percentage of cows

on test would provide more tested daughters per young sire sampled and increase the accuracy of the progeny test. Secondly, any improvement in AI techniques which would permit a sire to breed more cows per year would reduce the number of tested bulls needed. The actual load per tested sire in the example would be at least 7,000 services per year. The figure is almost three times the national average per sire, but is attainable.

Requiring fewer tested bulls allows either closer culling of the sampled young sires or more rigid selection when choosing young bulls for sampling. Either procedure permits the application of additional selection pressure on the males of the population.

Bratton *et al.* (5) have suggested that it is possible to obtain 25,000 to 50,000 progeny from an AI sire in 1 yr. Under similar rates of insemination, a stud breeding 150,000 cows would need to maintain a battery of from three to six tested sires, and would have to select only one or two replacements per year. The gain possible under the more optimistic estimate (50,000 progeny per sire per year) would equal that shown in Figure 1.

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PHYSICAL AND CHEMICAL CHANGES IN BOVINE SALIVA AND RUMEN LIQUID WITH DIFFERENT HAY-GRAIN RATIONS[1,2]

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SUMMARY

Saliva and rumen liquid samples were collected from two cows that were fed 20, 40, 60, 80, and 100% hay rations. The viscosity of saliva (mean 99 c.p.) was greater 3 hr. after feeding than before feeding and the pH (mean 8.2) increased as the proportion of hay increased. The ash of saliva (mean 0.73%) was greater with the high-grain rations. Total salivary nitrogen was 20.1 mg. % for the 20% hay ration and averaged 14.9 mg. % for the 40 to 100% hay rations. Hexosamines (mean 4.3 mg. %) were higher on the high-grain rations. The rumen liquid samples were centrifuged at 25,000 × G. and the supernatant analyzed. The mean dry matter content was 1.71% and the ash content was 0.79%. Sodium (mean 234 mg. %) increased as the hay content increased and was higher for the cow which tended to bloat than for the one which did not. Hexosamines (mean 3.7 mg. %) were also greater for the bloaty cow, but tended to increase in both cows with increasing proportions of grain. The total nitrogen of rumen liquid (mean 37.1 mg %) was highest on the 20% hay rations, was higher after feeding than before, and was higher for the bloaty cow than for the one which did not bloat.

It has been shown that ruminant saliva performs the dual function of lubricating the feed and buffering the rumen (3, 6, 8). The conservation of nitrogen, by salivary secretion of urea, constitutes a third function and demonstrates the ability of saliva to alter the chemical composition of the rumen (5, 9). Weiss (12) has shown that salivation is affected by the ration and that this results in an alteration of the physical condition of the rumen. This was offered as an explanation for the froth which frequently occurs in the rumen of bloated cattle. Smith *et al.* (10) developed a high-grain ration which produced frothy bloat in most cows to which it was fed. The present study was initiated to determine whether any detectable physical or chemical changes occurred in saliva or in rumen fluid, which could be attributed to the grain content of the ration.

EXPERIMENTAL PROCEDURE

Saliva and rumen fluid were collected from two cows equipped with the plastic fistula plug designed by Hentschl *et al.* (4). One cow (T-2) was started on the feeding regime at the 20% grain : 80% hay level and at 3-wk. intervals 20% of the original weight of the hay was replaced by grain, as indicated in Table 1. The other cow (C-930) was started on 100% hay and progressed toward the 20% hay : 80% grain level in a similar manner. The hay was good-quality, second-cutting alfalfa. The grain mixture contained 77.5% ground corn, 20% soybean oil meal, 1% dicalcium phosphate, 1% calcium carbonate, 0.5% trace mineralized

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TABLE 1

Physical and chemical changes of bovine saliva as affected by different rations

		Ration					Average, all rations
	Grain (%)	20	40	60	80	100	
	Hay (%)	80	60	40	20	0	
	Animal						
Volume (ml. min.)	T-2	160.0	128.3	186.7	226.2	218.4	200.9
	C-930	189.3	213.2	255.0	257.2	174.9	
Viscosity (centipoise)	T-2	63.5	51.9	6.0	222.2	3.7	98.9
	C-930	346.2	17.1	8.8	264.3	5.3	
pH	T-2	8.07	8.25	8.23	8.30	8.17	8.21
	C-930	8.03	8.21	8.13	8.33	8.37	
Dry matter (g. 100 ml.)	T-2	1.09	1.18	1.03	1.10	1.06	1.12
	C-930	1.15	1.05	1.11	1.16	1.26	
Ash (g. 100 ml.)	T-2	0.82	0.76	0.69	0.73	0.61	0.73
	C-930	0.82	0.74	0.72	0.80	0.64	
Total N (mg. %)	T-2	16.7	16.2	15.1	12.7	16.1	15.9
	C-930	23.4	10.1	19.4	14.0	15.5	
Sodium (mg. %)	T-2	340	320	299	310	284	305
	C-930	290	288	315	333	276	
Potassium (mg. %)	T-2	30	50	38	23	30	53
	C-930	133	109	38	29	49	
Calcium (mg. %)	T-2	1.80	2.91	2.83	2.27	2.23	2.57
	C-930	3.25	2.80	2.65	2.73	2.26	
Magnesium (mg. %)	T-2	1.00	2.65	2.36	2.46	2.95	2.52
	C-930	2.85	3.93	2.55	2.65	1.77	
Phosphorus (mg. %)	T-2	31.51	32.00	32.80	24.80	32.00	30.20
	C-930	24.58	31.50	32.00	30.50	30.30	
Hexosamines (mg. %)	T-2	5.2	6.2	4.3	1.7	2.0	4.3
	C-930	5.3	5.7	4.3	4.9	2.9	
Urea (mg. %)	T-2	7.28	6.64	6.58	6.02	5.80	5.68
	C-930	3.64	3.10	4.68	6.44	6.66	
80% Alc.-sol. Org. Matter (mg. %)	T-2	269	555	262	458	194	380
	C-930	273	318	501	605	364	
80% Alc.-sol.N. (mg. %)	T-2	9.1	11.7	12.9	11.8	16.1	11.7
	C-930	13.6	4.0	11.7	16.2	10.1	

salt plus supplemental vitamins A and D. Hay and grain were fed once daily in the morning at the rate of 1.5 to 2.0 lb. of feed per 100 lb. of body weight. T-2 weighed approximately 1,200 lb. throughout the trial, whereas C-930 increased in weight from 500 to 780 lb.

After the animals had been on the ration for 3 wk., samples were taken either just before or 3 hr. after feeding. Saliva was collected under slightly reduced pressure by the method of McGilliard *et al.* (7). A glass tube was introduced through the rumen fistula and inserted into the cardia of the esophagus. The viscosity of the salivas was determined at room temperature within 0.5 hr. after collection, using a falling ball apparatus. Carbon dioxide–combining power and pH were determined on fresh samples equilibrated with 5% CO_2 in nitrogen. Total nitrogen was determined on the fresh samples by micro-Kjeldahl digestion, followed by direct nesslerization. Rumen liquid samples were taken after mixing the rumen contents with the arm. These samples were centrifuged at 25,000 × G. for 20 min. to remove the bacteria. All supernatant samples were either frozen

or precipitated with 4 vol. of absolute ethanol and stored at −10° C. until analyzed.

Dry matter was determined by evaporating 50 ml. of saliva, or supernatant rumen fluid, or 200 ml. of the 80% ethanol filtrate to dryness in the steam bath. The samples were then placed in an oven and dried to constant weight at 105° C. Ashing was carried out at 600° C. A Van Slyke apparatus was used for determining CO_2-combining power and a glass electrode for the determination of pH. Hexosamines were determined by the method of Boas (2), simplified by elimination of the ion-exchange purification procedure. Two-milliliter samples were pricipitated with 50 ml. of *N* HCl on the steam bath for 4 hr. Urea-nitrogen was determined by aeration and titration of the ammonia liberated by urease. Sodium and potassium were determined on a Perkin-Elmer flame photometer, Model 52A. Calcium, magnesium, and phosphorus were determined by standard A.O.A.C. precipitation methods (1). Statistical analyses were made by analysis of variance, using ration, cows, and time of sampling as sources of variance (11).

RESULTS AND DISCUSSION

The results obtained for saliva are presented in Table 1. Each value represents the mean of two collections, one before feeding and one 3 hr. after feeding. The volume of saliva from C-930 was adjusted to that of a 1,200-lb. cow by dividing the rate of flow by the body weight and multiplying by 1,200. This permitted a direct comparison with T-2. On the basis of this calculation, there were no appreciable or significant differences in the volume of saliva secreted by the two cows. This might be expected, since the cardial method of collection stimulates salivary flow. McGilliard *et al.* (7) obtained a salivary flow of 211 ml. per minute by cardial collection, compared to a nonstimulated flow of 25 ml. per minute via the esophageal fistula in this same animal. No other values were corrected for body weight.

The viscosity of the saliva was extremely variable, but tended to be greater after feeding than before feeding and also tended to be higher on the rations containing 20 and 80% hay. Viscosity was the only property of saliva which appeared to vary with time relative to feeding. The pH increased as the per cent of hay in the ration increased. This tendency was significant at the 5% confidence level. The mean CO_2-combining power (276 vol. %, room temperature) and dry matter content of the saliva were not affected by rations, animals, or time. The ash concentration varied significantly ($P < 0.01$) with the proportion of concentrates in the ration. The mean total salivary nitrogen concentration was higher for the 20% hay : 80% grain ration than for the mean of all the other rations ($P = 0.02$). This may be a reflection of the higher protein content of the grain, compared to the hay, and would thus confirm the nitrogen-conserving action of saliva as noted by Simonnet (9). In this experiment, however, salivary nitrogen did not appear to vary in the regular manner with the level of grain in the ration, which would be expected on the basis of this explanation.

The salivary sodium and potassium seemed to vary inversely with each other. The sum of sodium plus potassium increased as the proportion of grain increased,

causing a significant ration difference at the 1% confidence level. The mean sodium plus potassium concentration for C-930 was somewhat higher than that for T-2 ($P < 0.05$); whereas, the phosphorus content was higher for T-2 than for C-930 ($P = 0.05$).

The concentration of hexosamines in saliva was higher on the high-grain rations (P approaches 5%), which was indicative of a higher mucoprotein content. This also was true for the 80% ethanol-insoluble nitrogen, which closely paralleled the hexosamine content, since the mucoproteins were precipitated by ethanol. Some loss in total nitrogen occurred during storage of frozen samples. This loss appeared to be largely urea-nitrogen, which might explain the failure of salivary urea to reflect the higher protein content of the high-grain rations. This would be expected from the results of Lewis (5), who observed urea-nitrogen concentrations from 15 to 36 mg. % in orally collected saliva. The higher values were obtained several hours after feeding high-protein rations.

The results obtained for the rumen liquid are presented in Table 2. The dry matter and ash content of the rumen liquid from T-2 increased as the per cent of grain increased in the ration; whereas, this change was not as constant for C-930. The dry matter, organic matter, and ash concentrations were all somewhat higher in the liquid from T-2 (P approaches 5%). The sodium concentration increased as the amount of hay increased in the ration and was greater for T-2 than for C-930 ($P < 0.05$). These differences do not appear to be related to changes in the composition of the saliva.

The concentrations of total nitrogen and ethanol-soluble nitrogen were higher after feeding and were greater for T-2 than for C-930 ($P < 0.01$). Both of these nitrogen fractions tended to be higher on the high-grain ration. The hexosamines

TABLE 2

Chemical changes in rumen liquid as affected by different rations

	Ration						Average, all rations
	Hay (%)	20	40	60	80	100	
	Grain (%)	80	60	40	20	0	
	Animal						
Dry matter (%)	T-2	2.22	2.01	1.90	1.64	1.50	1.71
	C-930	1.66	1.18	1.55	1.67	1.77	
Ash (%)	T-2	0.91	0.91	0.92	0.79	0.78	0.79
	C-930	0.75	0.54	0.68	0.80	0.80	
Total N (mg. %)	T-2	49.5	36.5	46.0	37.5	41.5	37.1
	C-930	43.0	24.5	26.0	39.5	27.0	
Sodium (mg. %)	T-2	243	275	269	276	276	234
	C-930	130	161	233	233	248	
Potassium (mg. %)	T-2	230	143	154	108	90	143
	C-930	159	118	115	144	173	
80% Alc.-sol. Org. matter (mg. %)	T-2	797	657	863	609	779	759
	C-930	723	679	700	820	961	
80% Alc.-sol. N. (mg. %)	T-2	34.0	28.5	39.0	32.5	25.0	27.3
	C-930	20.5	18.5	21.0	33.5	20.5	
Hexosamines (mg. %)	T-2	5.0	4.2	6.4	3.0	3.8	3.7
	C-930	6.0	2.2	2.2	2.1	1.6	

of the rumen liquid tend to increase with increasing grain in the ration (P approaches 5%). This tendency paralleled the trend noted in saliva.

The rumen liquid of the cow subject to bloat (T-2) contained more of the following constituents than that from C-930: dry matter, organic matter, ash, sodium, hexosamines, total nitrogen, and 80% ethanol-soluble nitrogen. The saliva from T-2 contained less sodium plus potassium and more phosphorus than the saliva from C-930. There is not enough information at present to speculate on whether these differences are associated directly or indirectly with the tendency to bloat, either through association with froth or otherwise. However, this possibility is indicated, particularly with the nitrogen fractions.

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EFFECT OF SEVERAL VARIABLES ON IN VITRO RUMEN FERMENTATION[1]

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SUMMARY

In vitro rumen fermentations were carried out in which the effect of several variables on dry matter and cellulose digestion and/or volatile fatty acid production was determined. With the regimes imposed, it was shown that percentages of cellulose and dry matter digestibility were improved by a reduced concentration of substrate and an increase in rumen liquor. Mineral media concentration had little effect within the ranges employed. Different sources of rumen liquor at times had marked effects on substrate digestion, with significant differences observed between twin steers in two trials. Adjustment of pH was shown to have a significant influence on cellulose digestibility, with indications that the optimum pH may be dependent to some extent on the rumen liquor source. Decreasing particle size of an alfalfa substrate was observed to depress dry matter and cellulose digestibility, but had no effect on peavine hay.

Fritted glass disc crucibles were used to estimate dry matter digestion. The correlation between these data so determined, and cellulose digestibility on a limited number of comparisons, was .96 ($P < 0.01$).

Since the introduction of in vitro research with rumen microorganisms, a wide variety of techniques has been developed by scientists interested in the microbiology and biochemistry of the rumen. Objectives in various laboratories may differ, and one technique may be more useful than another; consequently, there has been no attempt made to develop a standard procedure. Reports by Pigden and Bell (24) and Barnett (3) indicate that in vitro procedures may provide a good estimate of in vivo digestion of TDN and crude fiber. More recently, papers by Hershberger *et al.* (13), Baumgardt *et al.* (5), and Quicke *et al.* (25) indicate good correlations between in vivo and in vitro estimates of nutrient utilization by ruminants. If data from experiments of this type are to be extrapolated to other conditions and other laboratories, it seems likely that consideration of the several variables which may be encountered in this type of research is required.

The data reported herein are the result of studies designed to test the effect of several variables commonly encountered during in vitro rumen fermentations.

EXPERIMENTAL PROCEDURE

Essentially, the in vitro procedures used in this laboratory were the same as reported by Barnett and Reid (4). The mineral medium employed throughout was a slight modification of that reported by Lambert and Jacobson (19) and was used at a concentration of 7.11 g/liter. The following analyses were made: cellulose, by a modification of the procedure of Crampton and Maynard (10);

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total steam-volatile acids (expressed as milligrams acetic acid); and dry matter digestibility.

Fritted glass disc crucibles, 40-μ pore size, were used to estimate dry matter digestibility and have proven to be quite convenient. An appreciable amount of time saving is possible compared to routine cellulose analysis, since only oven-dry weights are required after filtering with suction. Crucibles of this type can be cleaned with reagents commonly found in the laboratory, and do not require weighing before use. It is assumed that any material which passes through the filter is digestible, an assumption which seems reasonable in view of the small pore size. A study with a limited amount of data (42 comparisons) revealed a correlation (r) of .961 ($P < 0.01$) between dry matter digestibility so analyzed and cellulose digestion. This indicates that approximately 92% (r^2) of the variation in dry matter digestion is accounted for by changes in cellulose digestion under the conditions imposed.

Variables tested in these experiments included: (a) amount of substrate, rumen liquor, and mineral solution, (b) source of rumen liquor, (c) pH adjustment, and (4) particle size of roughage substrates. Depending somewhat on the experimental design used, the data, for the most part, are the results of analyses of two subsamples from each of two replicates. All data were analyzed statistically by procedures outlined by Cochran and Cox (9).

Experiment 1. The objective of this experiment was to characterize the response of dry matter digestibility, cellulose digestibility, and volatile fatty acid (VFA) production to varying concentrations of rumen liquor, mineral, and substrate (alta fescue), each in combination with varying concentrations of the other. The experimental design was a second-order central composite design in three incomplete blocks, as described in Cochran and Cox (9), Plan 8A.4, p. 373. The 20 treatments used in the experiment are presented in Table 2.

TABLE 1

Analysis of variance of per cent dry matter digestibility, per cent cellulose digestibility, and volatile fatty acids

Source of variation	Degrees of freedom	Mean square		
		% D. M. digestibility	% Cellulose digestibility	VFA
Between runs	2	12.9460*	32.7828*	354010*
Liquor	1	30.7365**	37.4307*	284992*
Mineral	1	1.7734	10.4950	65875
Substrate	1	257.2072**	60.2027*	23275668**
Liquor × mineral	1	211.3568**	4.4259	73912
Liquor × substrate	1	69.1488**	0.0947	40760
Mineral × substrate	1	23.1200*	0.0253	224128**
$(\text{Liquor})^2$	1	0.1604	2.5036	1725
$(\text{Mineral})^2$	1	0.9728	2.4396	707
$(\text{Substrate})^2$	1	24.4948**	0.9471	338
Lack of fit	5	4.2043	3.1416	19133
Experimental error	3	0.7710	2.2164	18375
Coefficient of variation		1.1%	2.9%	4.3%
Multiple correlation coefficient		0.9276	0.7652	9.9825**

* $P < 0.05$.
** $P < 0.01$.

TABLE 2

Comparison of observed and predicted values of per cent dry matter digestibility, per cent cellulose digestibility, and VFA production

Treatment[a]			Dry matter digestion, per cent		Cellulose digestion, per cent		VFA production (mg.)[b]	
L	M	S	Observed	Predicted	Observed	Predicted	Observed	Predicted
40	40	5	85.24	87.07	75.38	77.88	1,825	1,985
100	40	5	88.20	88.09	82.02	80.10	1,784	1,943
40	100	5	87.65	86.93	80.01	78.18	1,548	1,599
100	100	5	88.50	90.51	80.46	83.36	1,647	1,941
40	40	15	78.48	77.97	75.12	73.98	4,127	4,151
100	40	15	78.36	80.47	72.16	75.64	4,127	4,411
40	100	15	75.36	76.99	70.36	74.16	4,275	4,443
100	100	15	82.36	82.05	79.54	78.78	4,903	5,059
20	70	10	80.62	80.00	76.87	75.60	3,060	2,970
120	70	10	86.58	84.97	82.40	81.09	3,833	3,447
70	20	10	82.82	81.47	77.74	76.86	3,266	3,046
70	120	10	83.52	82.65	81.50	79.77	3,527	3,275
70	70	2	94.69	93.58	80.10	79.88	1,290	1,035
70	70	18	80.36	79.24	75.42	72.96	5,569	5,350
70	70	10	82.66	82.78	77.03	77.17	3,153	3,179

[a] L, milliliters rumen liquor; M, milliliters mineral solution; S, gram substrate (alta fescue).
[b] Expressed as milligrams acetic acid.

There were several reasons for selecting this particular design for this experiment. It permits the simultaneous evaluation of the effect of the three variables over a wide range of concentrations, with considerably fewer treatments than would have been required had a full factorial set of combinations been used. In addition, the equipment used in this study permitted a maximum of eight digestions per trial. Hence, some form of incomplete block design was required.

The data were analyzed to estimate the linear, quadratic, and first-order interaction effects of the three variables on dry matter digestibility, cellulose digestibility, and VFA production. From these analyses, equations were derived relating digestibility to the concentration of liquor, mineral, and substrate.

Experiment 2. The objectives of this experiment were to determine if rumen liquor of markedly different origin might respond differently to substrates which varied widely in composition. A randomized block experimental design was used for each of four substrate fermentations. Rumen liquor was obtained for each series of fermentations from (a) a fistulated steer (FS) being fed a high-roughage pellet, (b) from a fistulated cow (FC) grazing on lush grass pasture, and (c) a mixture from at least two slaughtered cattle obtained from a local slaughterhouse (SH) and for which no previous nutritional history was available. In all cases the SH juice appeared to originate predominantly from grazing animals. The three liquor sources were used for individual fermentations of alta fescue, alfalfa hay, purified wood cellulose (Solka-Floc 40A), and a mixed high-roughage ration (66% alfalfa hay). The fescue had been clipped, frozen, dried, and ground, and was highly digestible (29). The alfalfa hay was coarse and stemmy. Data from the experiment are presented in Table 3.

Experiment 3. Since available data (12) indicate that twin cattle respond quite similarly to changes in environment, this experiment was designed to test

TABLE 3
Effect of different rumen liquor sources on digestion of dry matter and cellulose, and VFA production from different substrates

	Dry matter digestibility (%)[b]			Cellulose digestibility (%)[b]			VFA, mg. (%)[b, c]		
Liquor source[a]	SH	FC	FS	SH	FC	FS	SH	FC	FC
Substrate									
Fescue	79.2	81.2	83.2	71.6	80.8	77.8	301	338	309
Alfalfa hay	69.7	68.2	69.3	60.5	57.3	61.6	282	313	310
Solka-Floc	76.2	26.9	43.2	79.0	27.6	39.6	407	104	169
Beef pellet	74.4	74.2	75.5	64.5	62.6	66.1			

[a] SH, slaughterhouse; FC, fistulated cow; FS, fistulated steer.
[b] Means underscored by the same line are not significantly different ($P > 0.99$).
[c] Expressed as milligrams of acetic acid.

the effect of pH adjustment on rumen fermentations originating from fistulated twin steers (assumed to be monozygotic). A randomized block design was used in each trial. Fermentations were done after an extensive adaptation period to the original ration used (Trial 1), after a short period on grass (Trial 2), and after being on grass about 1 mo. (Trial 3). Rumen liquor from each of the steers was used for various substrate fermentations in which the pH was adjusted periodically with the aid of a Coleman pH meter to values of 6.5, 6.6, 6.7, and 6.8 during Trial 1 (alta fescue, Culture No. 232), to 6.2, 6.6, and 7.0 in Trial 2 (alta fescue, Culture No. 215), and to 6.5, 6.7, 6.9, and 7.1 in Trial 3 (Solka-Floc 40A). Data are presented in Table 4.

Experiment 4. In vivo digestion experiments suggest (20) that finely ground feed is sometimes less digestible than more coarsely ground feeds. The objective of this experiment was to determine if, under the conditions imposed, particle size of a roughage substrate might alter in vitro digestion. A completely randomized design was employed in each trial. Two substrates, alfalfa hay and peavine hay, were ground through 20, 40, 60, and 80 mesh Wiley mill screens and subjected to fermentation. Data on cellulose digestion are presented in Table 5.

RESULTS

Experiment 1. The analyses of variance of per cent dry matter digestibility, per cent cellulose digestibility, and VFA production are presented in Table 1.

The equations relating digestibility to the concentrations of the three variables are:

(a) $\%$ D.M. digestibility $= 82.78 + 1.52\,L + 0.36\,M - 4.39\,S + 0.64\,LM + 0.37\,LS - 0.21\,MS - 0.11\,L^2 - 0.27\,M^2 + 1.36\,S^2$

(b) $\%$ cellulose digestibility $= 77.17 + 1.68\,L + 0.89\,M - 2.12\,S + 0.74\,LM - 0.11\,LS - 0.06\,MS + 0.44\,L^2 + 0.43\,M^2 - 0.28\,S^2$

(c) VFA production $= 3{,}179 + 146\,L + 70\,M + 1{,}321\,S + 96\,LM + 71\,LS + 176\,MS + 11\,L^2 - 7\,M^2 + 5\,S^2$

in which

$L = (\text{Liquor Concentration} - 70)/30$

TABLE 4

Effect of pH on in vitro cellulose digestion by rumen liquor from twin steers

	Cellulose digestion (%)													
	Trial 1[a]					Trial 2[b]				Trial 3[c]				
pH	6.5	6.6	6.7	6.8	Mean	6.2	6.6	7.0	Mean	6.5	6.7	6.9	7.1	Mean
Twin No. 1	83.6	82.4	82.6	83.0	82.89	55.8	63.3	69.7	62.93**	35.1	39.8	29.5	10.3	28.68**
Twin No. 2	82.0	82.5	83.8	83.6	83.02	43.6	53.1	59.2	51.95	25.5	33.8	13.9	17.5	22.68
Mean[d]	82.90	82.42	83.19	83.32		49.70	58.20	64.42		30.30	36.80	21.70	13.90	

[a] Substrate was alta fescue, culture No. 232; rumen liquor from steers on a ration of grass hay, barley, and protein supplement; 70-hr. fermentation.
[b] Substrate was alta fescue, culture No. 215; rumen liquor steers after being on grass for ten days; 48-hr. fermentation. $P > 0.99$.
[c] Substrate was Solka-Floc 40A; rumen liquor from steers pastured on grass about 1 mo.; 48-hr. fermentation. $P > 0.99$.
[d] Means underscored by the same line are not significantly different.
** $P < 0.99$.

TABLE 5

Effect of particle size on in vitro digestion of dry matter and cellulose

	Alfalfa hay								Peavine hay			
	Trial 1[b]				Trial 2[c]				Trial 3			
Particle size[a]	20	40	60	80	20	40	60	80	20	40	60	80
D.M. (%)[d]	71.0	66.8	65.4	62.7	72.5	70.4	67.4	64.0	69.2	68.3	69.6	69.5
Cellulose (%)[d]	56.9	52.8	50.8	52.4	55.0	54.2	46.7	37.4	49.6	50.1	49.9	47.0

[a] Wiley Mill screen sizes.
[b] $P > 0.95$.
[c] $P > 0.99$.
[d] Means underscored by the same line are not significantly different.

$M = (\text{Mineral Concentration} - 70)/30$

$S = (\text{Substrate Concentration} - 10)/5$

That these equations adequately represent the response of digestibility to changes in concentration in liquor, mineral, and substrate over the range studied is indicated by the magnitude of the lack-of-fit term in the analyses of variance (Table 1). This term, which measures the failure of the derived equations to describe the digestibility response, is in no case significantly greater than experimental error. The close agreement between digestibilities observed for the various treatment combinations and those obtained by substituting appropriate values for liquor, mineral, and substrate in Equations (a), (b), and (c) may be seen in Table 2.

The response of per cent dry matter digestibility to varying concentrations of liquor and substrate at three mineral concentrations is graphically portrayed in Figures 1–3. These graphs were obtained from the solution of Equation (a) at each of several liquor and substrate levels.

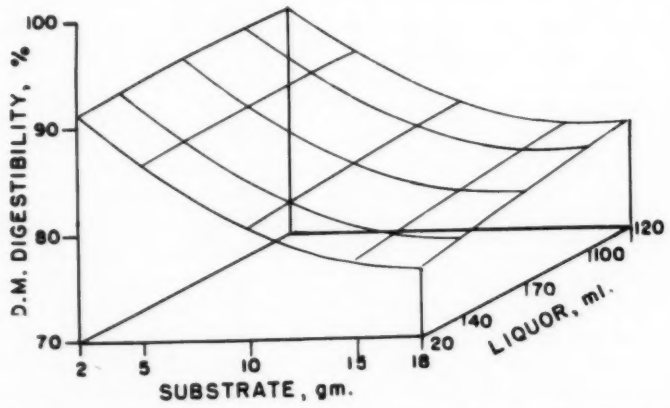

FIG. 1. Response of dry matter digestibility to changes in substrate and liquor concentrations at a mineral concentration of 20 ml. per flask.

From the foregoing results, it is apparent that over the range of concentrations used, substrate level profoundly affected the per cent dry matter digestibility. As substrate concentration increased from 2 to 18 g., dry matter digestibility approached a minimum. As indicated by the $L \times S$ and $L \times M$ interactions (Table 1; Figures 1–3), the point at which the minimum was reached depended on the concentration of liquor present and, to a lesser extent, on mineral concentration.

There was almost a linear increase in per cent dry matter digestibility as the volume of liquor was increased from 20 to 120 ml. The rate of increase, however, depended on the concentration of both mineral and substrate, being greater at the higher than at the lower mineral and substrate levels. Except as it affected the

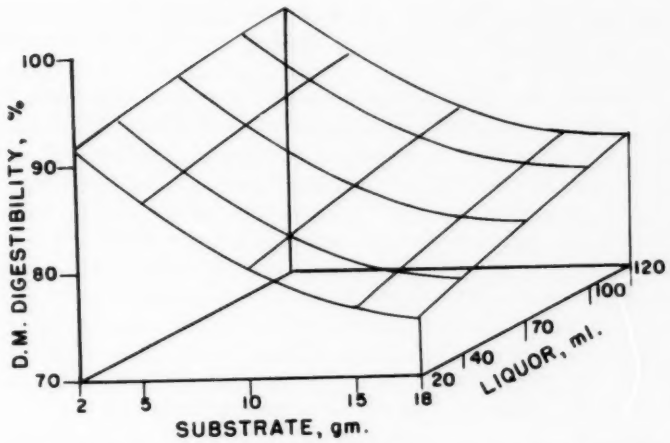

FIG. 2. Response of dry matter digestibility to changes in substrate and liquor concentrations at a mineral concentration of 70 ml. per flask.

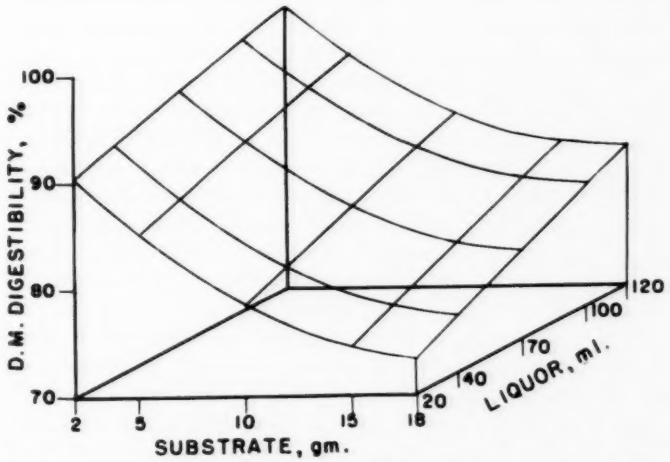

FIG. 3. Response of dry matter digestibility to changes in substrate and liquor concentrations at a mineral concentration of 120 ml. per flask.

response to liquor and substrate levels, the concentration of mineral had little effect on per cent dry matter digestibility.

Cellulose digestibility was affected only by changes in liquor and substrate concentrations. As the liquor level was increased from 20 to 120 ml., per cent cellulose digestibility showed a nearly linear increase. Conversely, as the substrate level was increased from 2 to 18 g., per cent cellulose digestibility decreased in a linear manner (total cellulose digestion increased). These effects were each

independent of the concentration of the other and of the level of mineral. As with dry matter digestibility, per cent cellulose digestibility was not affected by changes in mineral concentration.

VFA production depended, to a considerable extent, on the concentration of substrate. As the substrate level was increased from 2 to 18 g., VFA production increased by a factor of five. This increase depended, to some extent, on the concentration of mineral present, being higher at high mineral levels than at low. There was also a tendency for VFA production to increase as the concentration of liquor increased. Again, the level of mineral affected VFA production only in an indirect manner by its influence on the substrate effect. The data on VFA production might be somewhat more comparable to results on dry matter and cellulose if they were expressed on the basis of milligrams VFA produced per gram of substrate. However, since varying amounts of dry matter were added via the liquor itself, part of which undoubtedly contributed to VFA production, the data are shown simply in terms of total concentration.

Experiment 2. As shown in Table 3, there were no significant differences among rumen liquor sources except when wood cellulose was the substrate. The marked difference in response to the various rumen liquors in the digestion of the wood cellulose possibly may be explained by the fact that no additional nitrogen or soluble carbohydrates were added to the medium, so that qualitative and quantitative differences in the rumen liquors were, most probably, responsible for the differences observed. Although the cause of the variability is not known, the data illustrate the extreme differences that may occur with purified substrates in respect to digestion of cellulose and dry matter as well as VFA production.

It is of interest to note the differences between the FC and the FS rumen liquors. The fescue should have most nearly approached the feed from which the FC liquor originated. Only with fescue did the FC liquor digest more cellulose (nonsignificant difference) than did the FS liquor which originated from a steer fed a high-roughage pellet. No generalizations can be made concerning the SH liquors, since their histories were unknown.

Experiment 3. The data from this experiment (Table 4) show that after an adjustment period of approximately 6 wk., to allow stabilization of rumen microorganisms, no differences in cellulose digestion were observed between rumen liquor from twin steers or between flasks adjusted to pH levels of 6.5 to 6.8 (Trial 1). Unpublished data from this laboratory indicate that pH adjustment above 6.8 did not increase either cellulose or dry matter digestion for the substrate and rumen liquor used in Trial 1.

In Trial 2, cellulose digestion was increased ($P>0.99$) by upward adjustment of the pH from 6.6 to 7.0 on a fescue culture essentially identical to that used in Trial 1. In addition, there was a significant difference ($P > 0.99$) between steers. Rumen liquor used in this trial was obtained after the steers had been on pasture for about ten days. In Trial 3, the digestion of cellulose from a purified source was depressed ($P > 0.99$) by adjustment of pH levels to 6.9 or 7.1, and a significant difference ($P > 0.99$) still existed between steers.

The data from Trials 2 and 3 appear to be somewhat conflicting, and it is possible that the increase in cellulose digestion occurring in Trial 2 at pH 7.0

is an artifact. The differences between steers possibly may be explained by the fact that some dry feed (both grain and hay) was still being offered, although grass was available. It seems likely that the steers did not eat similar rations. No information is available on this point, since both steers were fed in the same pen.

Experiment 4. Examination of data in Table 5 shows that at least under some conditions, the particle size of the roughage substrate has some effect on in vitro digestion. There was a decrease ($P > 0.95$) in dry matter digestion in Trial 1 as particle size decreased, although there was no influence on cellulose digestion. In Trial 2 the digestion of both dry matter ($P > 0.99$) and cellulose ($P > 0.99$) was reduced as particle size decreased. It should be noted that the variation between subsamples and replicate flasks was higher than usually encountered in this laboratory with alfalfa hay as the substrate, especially in Trial 1. In Trial 3, when peavine hay was the substrate, there was no indication of a depression in digestibility, as smaller screen sizes were used.

DISCUSSION

There is a considerable volume of literature dealing with in vitro rumen fermentations and the techniques involved. Among the published papers, several authors have reported quantitative or qualitative differences in rumen liquor with regard to substrate fermentation, the utilization of other nutrients, or the production of end products. Some authors have pooled rumen liquor samples from several animals (4) or washed suspensions of microorganisms (16) as a means of reducing variability between inoculums. Stewart and Schultz (31), Salsbury *et al.* (28), and Quicke *et al.* (25) found little difference in cellulose digestion by various rumen liquor sources, although different techniques were employed. However, Hunt *et al.* (15) and Asplund *et al.* (1) have observed qualitative and quantitative differences in vitro for rumen liquors from steers fed different diets—information which would tend to be confirmed by data reported herein. Warner (32) has suggested that it is necessary to use as a test substrate only substances similar to the diet of the animal from which the rumen liquor originated, if the microbial population is to remain normal in numbers and activity. In view of the differences in cellulolytic microorganisms noted by Bryant and Burkey (6) from rumen samples of different origins, it would seem that a marked change from animal diet to in vitro test substrate would require an extreme shift in microbial population, accompanied by the possibility of misleading results.

Data reported herein have shown that increasing levels of dried grass, added to fermentation flasks, depress percentage digestibility of dry matter and cellulose, substantiating results reported by Cheng *et al.* (7) and Dehority *et al.* (11) with purified cellulose. Likewise, unpublished experiments from the Oregon Station, with alfalfa as a substrate, confirm the findings with grass. However, Huhtanen and Elliott (14) found that cellulose digestion was not influenced by the quantity of alfalfa added within the ranges studied and with the technique used, and Kamstra *et al.* (17) reported that adding increasing amounts of isolated plant celluloses resulted in increased digestion of cellulose.

Results reported herein indicate that the amount of rumen liquor may have an appreciable influence on the extent of in vitro digestion of cellulose or dry matter. This information tends to confirm that reported by MacLeod and Brumwell (21) and might be anticipated, especially with the use of purified substrates and washed cell suspensions (7).

Information presented herein (Experiment 1) demonstrated that changes in mineral medium concentration, within the ranges used, have only negligible effect on in vitro digestion of dry matter and cellulose or VFA production. The authors are not aware of any papers concerning the amount of complete mineral medium additions, although several papers concerned with trace minerals, phosphorus, or potassium have been published by the Iowa Station.

In many of the in vitro experiments reported, pH adjustments have been made in the range of 6.4 to 6.9. In some of the early literature, Wegner *et al.* (33) suggested adjustment between pH 6.0 and 7.5, whereas Meites *et al.* (22) have reported an optimum pH between 4.53 and 7.35 for cellulose digestion. More recently, Cline (8) found pH 6.9 to result in maximum cellulose digestion under the conditions imposed. Kitts and Underkofler (18) and Stanley and Kesler (30), working with isolated rumen cellulase preparations, found optimum cellulase activities at pH 5.5 and 5.5 to 6.0, respectively. With regard to constituents other than cellulose, Raun *et al.* (26) found a pH of about 5.5 to be optimum for phytate phosphorus utilization; Reis and Reid (27) observed that the optimum pH for ammonia accumulation varied between 6.0 and 6.7 on different diets and appeared to be correlated with the range of pH normally encountered in the rumen on each diet. Data from this laboratory would tend to confirm the results of Reis and Reid (27), in that the optimum pH for cellulose digestion would appear to vary according to substrate and/or source of rumen liquor.

A recent paper by Baker *et al.* (2) indicated little difference in digestion of purified wood cellulose when separated into different particle sizes; however, Virtanen (34) found that mesophilic bacteria fermented finely ground wood dust more completely than coarsely ground dust, possibly due to less interference by lignin. Observations reported herein indicate that the fermentation of some substrates (alfalfa hay) may be altered appreciably by fine grinding. No explanation is offered other than the possibility that fine grinding may have altered solubilities of other carbohydrate constituents, with a resultant change in cellulose-digesting flora.

To standardize conditions of in vitro fermentations within and between laboratories (if so desirable), for the purpose of evaluation of feedstuffs and comparisons thereof, it would appear that several variables should receive consideration. Information from papers reviewed and results of experiments reported herein indicate that rumen liquor source, pH adjustments, quantity of liquor and substrate, and particle size should be standardized, in so far as possible, within and between laboratories. Other variables such as length of fermentation, addition of trace minerals, and the effect of various techniques have been covered in numerous papers.

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TECHNICAL NOTES

INHIBITION OF OXIDIZED FLAVOR IN HOMOGENIZED MILK AS RELATED TO THE CONCENTRATION OF COPPER AND PHOSPHOLIPIDS PER UNIT OF FAT GLOBULE SURFACE

Inhibition of the development of oxidized and tallowy flavors in milk by homogenization is well known and is the best practical method to control these off-flavors in market milk. There has been no agreement or tenable postulate made as to why the development of oxidized flavor is retarded by homogenization.

The following explanations have been advanced:

(1) Migration of the unstable lipid component, presumably phospholipids, from the surface into the interior of fat globules (5).

(2) Partial removal of phospholipids from the fat globule membrane into the serum phase (8).

(3) "Irreversible change in the structural configuration of the copper protein lipid complex in such a way that ascorbic acid is no longer able to initiate the formation of lipid free radicals," as recently proposed by King (3).

The authors have tested the tenability of these explanations. Phospholipids were not removed from the fat globule membrane and did not migrate into the interior of the fat globules by homogenization. Samples of milk were homogenized at 1,000, 2,000, and 3,000 p.s.i.g., and separated to obtain cream containing 28% fat. The creams were washed free of lactose, frozen, rubbed in a mortar, warmed up, and filtered to obtain pure fat. The analysis of phosphorus in the fat obtained was determined by a sensitive micro-method (1). In seven different experiments no phosphorus was found in the pure fat of the homogenized milk.

There was a partial removal of phospholipids from the membrane during homogenization, but in no case did more than 20% of the phospholipids pass into the serum phase (4). Inhibition of oxidation can not be explained by this partial removal, because it is related to the pressure and no correlation was found between the depletion of phospholipids and the homogenization pressure (4).

King's (3) argument is so general and all-inclusive that its validity can not be readily proven or disproven, but if the structural changes in the copper-protein-lipid complex, brought about by homogenization, are irreversible in such a manner as to prevent the role of ascorbic acid to initiate the oxidative reaction, then the question arises, "At what homogenization pressure does this occur?" Inhibition of oxidized flavor by homogenization is not coincidental with any specific homogenization pressure. The greater the pressure, the greater the extent of inhibition. Furthermore, if it is to be explained on the basis of the blocking of ascorbic acid, then an additional amount of copper added, especially after homogenization, should not produce the development of typical oxidized flavor in homogenized milk. This is not the case, as can be seen from the data of Table 1.

In several experiments, it was found that when milk is homogenized from 500 to 3,000 p.s.i.g., the fat globule surface area on the average is increased from two to five times, depending on the pressure. These data are in accord with the literature (2). Homogenization did not increase the phospholipids in the newly formed fat globule membrane; in fact, they decreased slightly (4). The coper concentration in the membrane per unit weight of fat is somewhat increased by homogenization, due to adsorption of plasma proteins which bind only about 0.04 as much natural copper as the protein of the original membrane (6, 7). It is clear, therefore, that with the increase in the surface by homogenization, the concentration of phospholipids and the copper per unit of surface is decreased proportionally to the increase in surface area.

If the concentration of the phospholipids per unit of surface area, and especially that of copper as a catalyst, is a factor in the inhibition of oxidized flavor by homogenization, then the addition of copper before or after homogenization in such amounts as to bring the concentration of copper per unit of surface area to about the same level as before homogenization, should nullify the effect of homogenization. The data of Table 1 show that this is actually the case. The inhibition of the oxidative reaction by homogenization is not absolute; it is relative only to the extent of the increase in surface area. The amount of copper necessary to add before or after homogenization, to nullify the effect of homogenization, is related to the increase in surface area. In the experiments of Table 1, fresh mixed milk was heated at 77° C. for 5 sec., cooled at 40° C., and after the addition of an indicated amount of copper the milk was immediately homogenized. A Rannie laboratory homogenizer was used. Both control and homogenized samples were cooled to 3° C. and stored for 48 hr. at that temperature. The samples then were scored as unknowns by a panel of four experienced judges. In processing and storing the milk samples, care was taken to avoid the effects of light. Results identical to

TABLE 1

Relationship between the increase in surface area of milk fat globules by homogenization and the amount of copper necessary for the development of oxidized flavor

Total copper content	Organoleptic score	Size of fat globules (in μ)								Surface/g[a] of fat
		< 1	1	2	3	4	5	6	7	
(p.p.m.)		Control								*($cm.^2 \times 10^4$)*
0.05	0									
0.10	+	Per cent								
0.15	++	28	26	18	14	8	4	1.5	0.5	15.3
0.25	+++									
0.45	++++									
		Homogenized 500 p.s.i.g.								
		Per cent								
0.05	0									
0.25	++	54	27	8	6	4	1	....	....	21.7
0.55	+++									Ratio of
1.05	+++									surface
										increase; 1.42
		Homogenized 1,000 p.s.i.g.								
		Per cent								29.1
0.05	0									
0.25	+	67	20	8	4	1	....	....	....	Ratio of
0.55	++									surface
1.05	++									increase; 1.90
		Homogenized 3,000 p.s.i.g.								
0.05	0	Per cent								
0.25	0	83	15	2	....	....	....	....	....	70.9
0.55	+									Ratio of
1.05	+									surface
										increase; 4.63

0 = Normal. + = Slightly oxidized. ++ = Oxidized. +++ = Strongly oxidized. ++++ = Very strongly oxidized.

The original copper content of the milk was, in all cases, 0.05 p.p.m.

[a] For the determination of the surface area, the size of 500 fat globules was measured. For all fat globules smaller than 1 μ the average value of 0.5 μ was taken.

those of Table 1 were obtained when the copper was added immediately after homogenization.

The site of the oxidative reactions that cause the oxidized flavor in milk is the surface of the fat globules and the reactants are phospholipids and oxygen, catalyzed by the copper-protein complex. The concentration of the phospholipids and the copper-protein complex per unit of surface area is decreased proportionally to the homogenization pressure. This decrease in concentration per unit of the newly formed fat-globule surface area appears to be the most important factor, if not the only one, that retards the development of oxidized flavor in homogenized milk.

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THE ACTION OF PANCREATIC LIPASE ON MILK FAT[1, 2]

It has been established that the first product resulting from the action of pancreatic lipase on a triglyceride is the 1,2-diglyceride (1,6–9). Using this approach to the problem of glyceride structure, Mattson and Lutton (7) have shown that unsaturated acids of a large number of vegetables and animal fats occur preponderantly in the 2-position of the triglycerides. However, they found lard to be a distinct exception in that its 2-monoglycerides, derived by lipolysis, contain largely saturated acids. Milk fat is a notable omission from those fats studied, particularly in view of its dietary importance. As a consequence, information has been sought regarding the structure of milk fat glycerides.

The general design of 11 rather similar experiments to date has involved the following: (a) selective release of the fatty acids by digesting the fat with pancreatic lipase according to the procedure of Mattson and Beck (6), (b) fractionation of the digested lipids into triglycerides, fatty acids, di- and monoglycerides by silicic acid chromatography (3), with infrared spectrophotometry to confirm the identity of the fractions, (c) conversion of the acids in the various fractions after saponification to methyl esters (2), and (d) analysis of the methyl esters by gas chromatography. For this latter analysis, a Barber-Coleman Model 10 instrument was used.

The data of Table 1 are representative of experimental results from a sample of June (summer) milk fat. Data for a sample of early March (winter) fat have shown the same trends. The identity and recovery of the methyl esters by gas chromatography were checked by comparison with authentic reference compounds on both apiezon L (4) and diethyleneglycol succinate polyester (5) columns. Sample size, column packing (polyester), and operating condition of the gas chromatography instrument for the data in Table 1 were uniform. From these data it is evident that the 2-monoglycerides are somewhat enriched in the saturated acids C_{10} to C_{16} and particularly in C_{14} acid. They are poorer in the unsaturated acids, and in these respects milk fat tends to resemble the unique distribution of fatty acids observed for pig fat (7). Since Mattson and Lutton have shown that beef fat does not conform to such a distribution, it appears that at least two somewhat different pathways of triglyceride synthesis prevail in the bovine.

The fatty acids and triglycerides from the lipase digest were collected as one fraction, since they were not cleanly separated on the silicic acid column. In one experiment, the fatty acids were removed from the residual triglycerides by alkali washing. Methyl ester analysis indicated that these latter triglycerides are indistinguishable from unreacted fat. Thus, it does not appear that the lipase is particularly preferential in the triglycerides it attacks.

TABLE 1

Gas chromatographic analysis of methyl esters[a] from milk fat fractions produced by pancreatic lipase[b]

	Fat fraction			
	Intact fat	Fatty acids and triglycerides	Digycerides	Monoglycerides
Weight (*mg.*)	1,000	452	344	159
Methyl ester				
C_8	1.0	0.9	0.8	1.0
C_{10}	3.0	3.0	2.4	4.6
C_{12}	3.6	3.3	3.2	5.2
C_{14}	11	9	13	20
C_{16}	30	27	33	34
C_{18}	17	19	15	8.7
$C_{18}^{=}$	34	37	30	25
$C^{=}$	2.2	2.4	2.1	1.7

[a] Expressed as per cent of total chromatogram area and determined by triangulation.
[b] 20-min. digestion of a 1-g. fat sample.

In general, the data in Table 1 are mutually supporting, i.e., methyl esters which are low in the fatty acid–triglyceride fraction are higher in the diglycerides and highest in the monoglycerides. One obvious advantage of applying gas chromatography to the particular problem is its capacity to reveal the distribution of individual acids. For example, the behavior of the C_{18} saturated acid in these experiments is somewhat anomalous, in that its distribution does not parellel the other saturated acids but, instead, tends to follow the C_{18} unsaturated acids. On the other hand, gas chromatography is not a particularly convenient or reliable means of quantitative analysis for the methyl esters of both short and long chain acids. Thus, the distribution of the C_4 to C_8 acids is being evaluated by another analytical technique. Data on these acids, which do not invalidate the trends evident from Table 1, will be included in a more comprehensive report of this work.

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SOME EVIDENCE SUPPORTING THE SPECIFICITY OF MILK LIPASES FOR THE PRIMARY HYDROXYL POSITIONS OF MILK GLYCERIDES[1]

Pancreatic lipase has been shown to hydrolyze triglycerides to 2-monoglycerides (MG's), which will eventually isomerize to 1-MG's (7, 8, 9). Thus, pancreatic lipase specifically hydrolyzes the primary hydroxyl positions of glycerides. Information on this subject is almost completely lacking for milk lipases. The problem can be attacked in several ways, one of which involves the determination of 1- and 2-MG's in lipolyzed milk fat. From the relative concentrations the sequence of lipolysis can be ascertained, under certain circumstances. However, the isomerization of 2-MG to the 1-isomer, which is catalyzed by acid, heat, alkali, and chromatographic separation on silica-gel columns, complicates the picture (1, 2, 6). An equilibrium mixture of about 90% 1-MG and 10% 2-isomer eventually will be obtained (6). In a previous paper (5) 2-MG's were found in lipolyzed milk, but the concentrations of the 1- and 2-isomers were such that no conclusions could be made as to specificity, probably because isomerization occurred during storage of the milk samples at 4° C. for 24 hr. If milk lipases behave in the same manner as pancreatic lipase then, after a short period of hydrolysis, 2-MG's should be present in excess of 67% (8). If milk lipases attack both the primary and secondary positions then, barring isomerization, 2- and 1-MG's should occur at a ratio of 2:1. The purpose of this investigation was to determine the 1- and 2-MG contents of milk fat during short (2-hr.) hydrolysis periods at 37° C., with the hope that isomerization would be eliminated or reduced.

[1] This investigation was supported in part by a PHS research grant (A-2605 C1) from the National Institute of Arthritis and Metabolic Diseases, Public Health Service.

Pasteurized, homogenized milk, and raw milk were mixed in equal portions, split into six equal quantities placed in 250-ml. beakers, and incubated in a 37° C. water bath for periods up to 2 hr. Samples were taken at the moment of mixing and at 20-min. intervals during the 2-hr. period. Acid degree values (ADV's) were determined by the silica-gel method of Harper *et al.* (3) and 1- and 2-MG's as described by Jensen and Morgan (5). The experiment was repeated five times. Four of the raw milk samples were taken from individual cows and mixed with homogenized milk without cooling. The fifth raw sample was taken from mixed herd milk held in a bulk tank.

The results in Figure 1 indicate that milk lipases are specific for the primary hydroxyl position of milk fat glycerides. The lipases associated with induced lipolysis or plasma lipases undoubtedly were the enzymes involved, since homogenized milk was used and in four of the trials the raw milk was never allowed to cool (10). In the fifth trial, in which cooled, bulk raw milk was employed, dilution probably reduced or eliminated the activity of membrane lipase (11). Each point on the curves (Figure 1) represents the average of five determinations. The lines above and below the points indicate the maximum and minimum values obtained.

When the zero determinations were subtracted from subsequent values, the relative concentration of 2-MG averaged 82.3%, which clearly shows that milk lipases are specific for the primary positions. If the samples had been stored at 4° C. for 24 or 48 hr., enough isomerization would have occurred to reduce relative concentration of the 2-isomer to about 50-60% (4). It is evident from Figure 1 that isomerization of 2-MG to 1-MG occurred. This change

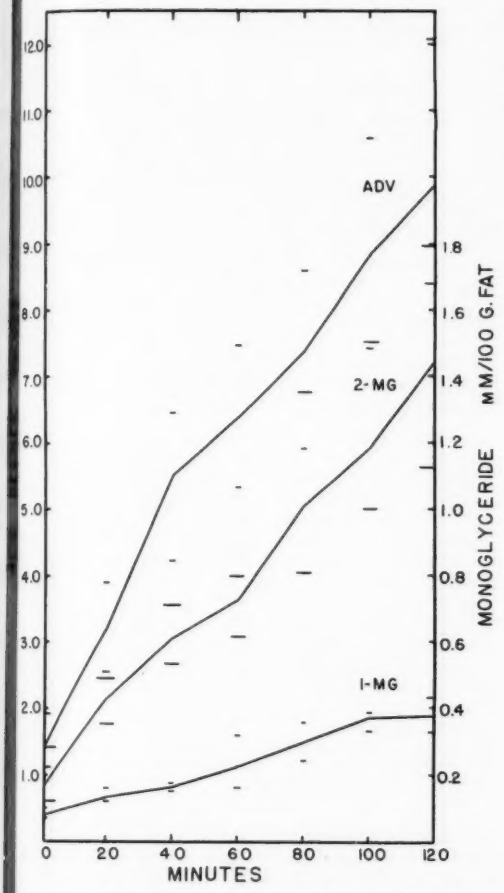

FIG. 1. The acid degree values (ADV's, silica-gel) and 1- and 2-monoglyceride (MG) contents of equal mixtures of raw and homogenized milk incubated at 37° C. for 2 hr. The short horizontal lines represent the maximum and minimum ADV's and 1-MG contents. The longer horizontal lines represent the same for the 2-MG contents.

was probably catalyzed by the fatty acids produced and by the silica-gel extraction method. Borgstrom (1) noted that 2-MG's isomerized to 1-MG when passed through a silicic acid chromatographic column. In the silica-gel method of extraction, the time of exposure of the MG's to silicic acid is quite short (5 min.), but some isomerization probably occurred. It is of interest that the relative concentration of the 2-MG at zero time averaged 64.4%. This quantity reveals that some lipolysis with accompanying isomerization of 2-MG to 1-MG had occurred in the milks previous to mixing.

As in a previous paper (5), the existence of diglycerides is indicated by the millimoles of fatty acids unaccounted for by the monoglycerides. It follows that the diglycerides must be predominantly of the 1,2-type.

The results shown in Figure 1 are the only sets of concentrations from which conclusions can be made regarding position specificity with data of this type. If the relative 2-MG concentration had been 67% or less, it would have been impossible to determine specificity because of isomerization. The authors regard the results presented in the paper as preliminary. Final proof of position specificity involves the lipolysis of special triglycerides with different acids in the 1- and 2-positions, as was done by Mattson and coworkers (7, 8, 9). This approach is now being studied in the authors' laboratory.

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COMPARATIVE SERUM CONSTITUENTS IN BRAHMAN AND ANGUS COWS[1]

Much interest has been manifested in the physiological factors that relate to performance of cattle under different environments. The adaptability of cattle to nutritional and environmental stress is thought to be related to genetic control of nutrient utilization. Consequently, many have studied levels of certain blood constituents in different breeds of cattle. Oklahoma workers (7) found little difference in levels of serum calcium, phosphorus, ascorbic acid, hemoglobin, carotene, or vitamin A between Hereford, Angus, and Shorthorn cattle. However, it has been well established that different breeds of dairy cattle vary markedly in levels of serum vitamin A and carotene. Texas workers found in Brahman breeds of cattle that the level of alkaline phosphatase (4) in the serum was twice as high and the reduced-glutathione content (5) was lower, compared to European breeds of cattle.

Serum protein fractions are important to nutrient utilization, since they form a transportation mechanism for many nonwater-soluble materials such as vitamin A, carotene (2), and cholesterol (1). In this regard, comparatively little attention has been given to ruminant animals.

In an attempt to determine differences between Brahman and European breeds of cattle, blood was withdrawn from ten Angus, 12 Brahman, and ten crossbred Angus-Brahman cows. The cows, aged from 2 to 6 yr., were reared in the same environment and all grazed alfalfa pasture. All data were subjected to analyses of variance and Duncan's multiple range test for significance (6).

Since other studies (8) have shown that SGO-T varied directly with environmental temperature in Hereford Cattle, the serum was analyzed for serum-glutamic-pyruvic and serum-glutamic-oxaloacetic transaminase (9). In this study, no breed differences were found in serum transaminase levels or when the serum was analyzed for cholesterol (10) (Table 1). When all sera were analyzed for vitamin A and carotene (3), the sera of Brahman cows was found to contain a significantly higher level of vitamin A and carotene as compared to Angus cows; the crossbreds were intermediate.

Serum protein, glycoprotein, and lipoprotein were separated by paper electrophoresis in a Durrum cell in sodium veronal buffer (pH = 8.6; $\mu = .075$) for 16 hr. (2.5 ma.) and dyed with bromophenol blue, Schiff's reagent, and oil red 0 dye, respectively. Both the Angus and crossbred cows contained a significantly greater albumin per cent than Brahman cows; whereas, the reverse was found in alpha globulin per cent. Beta globulin per cent was significantly greater in Brahman and crossbreds than in Angus cows. No significant breed differences were found in glycoprotein or lipoprotein fractions.

TABLE 1
Breed differences in serum constituents*

	Angus	Cross-bred	Brahman
SGO-T *(units/ml)*	36	36	37
SGP-T *(units/ml)*	57	56	55
Cholesterol *(mg. %)*	153	165	158
Carotene *g. %)*	[750	840]	[1226]
Vitamin A *(μg. %)*	[60.1	71.5]	[80.9]
Serum protein *(%)*			
Albumin	[44.7	47.6]	[40.6]
Alpha globulin	[12.7	12.7]	[14.6]
Beta globulin	[11.7]	[13.0	13.4]
Gamma globulin	30.9[c]	26.7[a]	31.3[b]
Glycoproteins			
Total[d]	81	69.2	80.3
Fraction I[e] *(%)*	8.7	9.4	7.0
Fraction II *(%)*	49.7	51.5	55.3
Fraction III *(%)*	41.6	39.1	37.7
Lipoproteins			
Total[d]	64.3	85.3	55.8
Alpha *(%)*	56.9	66.7	51.4
Beta *(%)*	10.1	6.3	8.2
Gamma *(%)*	33.0	27.0	40.4

* Data within brackets do not differ statistically.
[a] Differs significantly from [b] and [c], but [b] does not differ from [a].
[b] See note above.
[c] See note above.
[d] Based on total analytical counts.
[e] Numbered according to rate of movement; I moved the greatest distance.

While these data are limited, they will add to the further understanding of the physiological differences between European and Brahman breeds of cattle.

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EFFECT OF SOLAR RADIATION ON VARIATIONS OF BLOOD CONSTITUENTS IN CATTLE[1]

The physiological alterations occurring during heat stress, together with the measurements for assessing heat stress in animals, have long intrigued research workers. Stress caused by high ambient temperatures may be elevated further by the added heat load of solar radiation. Reimerschmidt (6) reported that a bull during a midsummer day absorbed enough heat from solar radiation to raise 44 gal. of water from 0° C. to boiling. Since the bovine animal does not possess a sweating mechanism like man, the primary process for heat dissipation is mediated via convection and conduction. Consequently, when ambient temperature surpasses body temperature, the animal must alter its physiological processes in the attempt to maintain homeostasis.

While considerable data are available in the literature concerning the alteration of blood constituents in animals subjected to high ambient temperatures, limited information can be found regarding the effect of the added heat-load from solar radiation.

A carotene and vitamin A free ration was fed to four sets of identical twin cattle (approximately 800 lb. body weight) for 6 mo. prior to and during the experimental period. One co-twin from each set of identical twins was subjected to direct sunlight, whereas the respective co-twins were penned under shade during high summer temperatures in Tucson. Blood was withdrawn from all cattle at 6-hr. intervals on one, 26, and 38 days of the experimental period, and analyzed for the following components: vitamin A and carotene (3), glucose (2), cholesterol (10), hemoglobin (2), creatinine (1), cholinesterase (2), serum glutamic-oxaloacetic transaminase (SGO-T) (7), and serum glutamic-pyruvic transaminase (SGP-T) (7).

All data were subjected to analyses of variance and the Student's "t" test (8). The diurnal variation of the blood constituents in animals subjected to solar radiation was not significantly different from that of their co-twins in the shade, in any of the three periods during progressive vitamin A depletion.

The average level of each blood component of cattle exposed to sunlight and shade in all periods was graphed (Figure 1) and compared

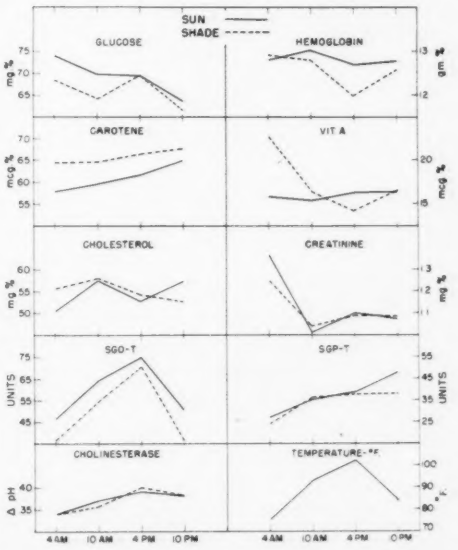

FIG. 1. Variations in level of blood components as influenced by diurnal ambient temperature changes.

[1] Arizona Agricultural Experiment Station contribution to the Regional Project W-46: The Effects of Environmental Stresses on Range Beef Cattle and Sheep Production. Arizona Agricultural Experiment Station Technical Paper No. 531.

to the mean daily temperature variations. Although these animals had been fed a carotene-vitamin A free ration for 6 mo. prior to this investigation, no profound vitamin A deficiency syndromes such as anasarca, blindness, and incoordination were observed. Previously, cattle devoid of vitamin A were unable to withstand high ambient temperatures and solar radiation in Arizona (4). Consequently, the effect of added stress from solar radiation may be profoundly different in critically deficient animals.

The elevated SGP-T and the direct fluctuations of SGO-T with increasing ambient temperature (Figure 1) would suggest that heat stress may predispose an increased gluconeogenesis. The accelerated expenditure of vitamin A in animals subjected to heat stress (5) may be the result of increased production of adrenal corticoids, since Wolf and associates (9) suggested that vitamin A may function in the synthesis of adrenal corticoids.

Although normal diurnal variation could not be separated from temperature effect, SGO-T appeared to be the best indicator for the assessment of heat stress in cattle.

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INTERPRETIVE SUMMARIES OF PAPERS

RELATIVE CLEANABILITY OF VARIOUS STAINLESS STEEL FINISHES AFTER SOILING WITH INOCULATED MILK SOLIDS[1, 2]

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A large difference of opinion is currently expressed by regulatory officials, equipment manufacturers, and representatives of the dairy and other food industries regarding the cleanability of stainless steel with the various common finishes. Because of the magnitude of the problem and its relation to efficient cleaning procedures, a comprehensive study involving representative stock supplies of stainless steel would be valuable. This applies to companies and agencies with direct interests in the fabrication, utilization, and the promulgation and enforcement of cleaning regulations pertaining to food processing equipment. Results of the study should provide a sound basis for the establishment of stainless steel finish purchase specifications in relation to ease of cleaning and sanitizing. This information has not been available to all concerned in the past.

The investigations reported in literature have been studies on the cleaning of various types of materials used in equipment, such as tinned iron, stainless steel, glass, and plastic. Some work has been done on finish cleanability by manual brushing, which has inherent weaknesses for studying relative cleanability; also, other studies have been reported on a limited number of finishes.

The purpose of this study was an investigation of relative cleanability by spray-cleaning techniques of No. 2B, 3, 4, and 7 stainless steel finishes on the commercial market. The No. 2B finish has no polishing. The surface remained unchanged from the rolling process during manufacture. The No. 3 finish was given to the surface by polishing with a 80-100 grit belt. The No. 4 finish was acquired by a 120-150 grit polishing and the No. 7 was attained by a 325 grit polishing plus a buffing.

Type 302 stainless steel panels, 8 by 8 in., were obtained from production stocks of the major United States stainless steel producers. Twelve panels from each finish were selected by a random sampling system.

The test areas of the panels were soiled by an application of skimmilk containing *Bacillus globigii*, and soil was dried with optimum conditions for adherence. Special precautions were taken to spray-clean all surfaces uniformly by the construction of an automatic washing device. The three cleaning procedures consisted of (1) a rinse only, (2) rinse plus washing solution spray and rinse, and (3) separate sprays of rinse, washing solution, rinse, and sanitizing solution.

[1] Contribution of the Michigan Agricultural Experiment Station No. 2482.

[2] Aided in part by the American Iron and Steel Institute and the National Association of Dairy Equipment Manufacturers.

Three bacteriological tests were used to determine the number of bacteria which remained under the mild cleaning conditions employed. The most critical test, the direct surface agar plate, measures the bacteria remaining on the surface of the steel. The common swab test was also used, since it is recognized as a standard procedure; this test determines the number of bacteria removed from the surface, as well as from the swab. The third test, the direct agar contact plate, was made by pressing a sterile agar slab against the steel surface to pick up the bacteria. Total recovery was not uniform by this method and was always less than obtained by any of the other tests. To eliminate errors of human judgment, a statistical plan was used to evaluate the data.

On the basis of the data obtained from the most critical test, no difference in cleanability with respect to bacteria was found among No. 2B, 3, 4, and 7 finishes after cleaning by mild rinsing only. No difference in bacterial cleanability of finishes was observed by the second cleaning procedure of spraying rinse water, wash solution at about 160° F. and rinse water, or, after the third procedure of rinsing, washing, and sanitizing with 100 p.p.m. of chlorine for 1 min. when the most critical test was employed.

Using the less sensitive swab test, a slight difference in cleanability between finishes was observed after mild rinsing; after rinsing and washing and rinsing, and after rinsing, washing, and chlorine sanitizing, no difference was observed.

With the least sensitive test, a difference in cleanability was noted among finishes after each of the three washing procedures.

Although only mild conditions of cleaning were employed, purposely to retain some bacteria on the surface, the experimental data were compared to the minimum recommended standard of 50 colonies per 4 sq. in. of area. With the most sensitive test, compliance with the standard was obtained 16, 14, 13, and 16% of the time on the No. 2B, 3, 4, and 7 finishes, respectively, after rinsing only. After cleaning by the second procedure, compliance was observed 100, 91, 96, and 93% of the time with the No. 2B, 3, 4, and 7 finishes. After the complete cleaning cycle of spray-rinsing, washing, and sanitizing, compliance was noted from 98 to 100% of the time. It is important to note that the utilization of a complete cleaning cycle of rinsing, washing, and sanitizing resulted in the desired degree of cleanability over 99% of the time; this degree of assurance is vital to proper dairy operation.

INFLUENCE OF VACUUM PASTERURIZATION UPON THE FREEZING POINT VALUE, TOTAL SOLIDS, AND CONCENTRATION OF FLUID MILK

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Vacuum pasteurization of milk has been accepted with approval by the dairy industry for the removal of off-flavors and for standardizing the flavor of fluid milk. Because some of the vacuum pasteurization systems inject steam into the milk, public health authorities became concerned because of the possibility of diluting the product. Public health authorities and milk plant operators were concerned with the use of the nonsteam-injection systems from the standpoint of concentration of the product and probable increase in plant loss. Several investigators have reported the results of vacuum treatment upon the physical properties of milk. It was the purpose of this investigation to study the effects of vacuum pasteurization without steam injection upon the freezing point value, total solids, and concentration of fluid milk.

Composite samples of raw and pasteurized milk were obtained during 3-hr. processing periods from the balance and surge tanks of a Vacu-Therm[1] pasteurizer. The temperature of pasteurization and the vacuum level were varied independently from 161 to 175° F. and from 22 to 26 in. Milk was pasteurized at the same temperature in an HTST for control purposes. During the operation of the Vacu-Therm, vapors from the vacuum chambers were condensed in the condenser section of the press and trapped. The rate of condensate per hour for each treatment was measured.

It was found that the total solids were higher in vacuum-pasteurized samples than in the corresponding raw samples, regardless of the treatment. The increase was small when the temperature drop (the difference between the pasteurizing temperature and the flashing temperature of milk in the second chamber of the Vacu-Therm) was less than 20° F. A temperature drop of more than 20° F. caused the total solids content of vacuum-pasteurized samples to increase markedly. Samples pasteurized in an HTST showed an increase in total solids of the same magnitude as those with a temperature drop of less than 20° F., which were pasteurized in the Vacu-Therm. The apparent increase of 0.05% was attributed to less selective drainage of the homogenized milk from weighing pipettes. Unhomogenized milk will drain selectively, from a pipette, proportionally larger amounts of fat than other solids remaining in the pipette, yielding a lower total solids value in the unhomogenized milk.

The freezing point values of HTST samples were similar to those of raw milk samples. The freezing point values of vacuum-pasteurized samples were not similar to those of raw milk. Vacuum pasteurization with a temperature drop of less than 20° F. raised the freezing point value (decreased depression)

[1] Vacu-Therm Pasteurizer, De Laval Separator Co., Poughkeepsie, N. Y.

0.006° C., which is equivalent to 1% of added water. As no water entered the milk, this is an apparent dilution. The same temperatures of pasteurization in an HTST showed no change in the freezing point value of the pasteurized samples, ruling out milk salt precipitation. The change is attributed to the removal of dissolved gases from the milk by vacuum pasteurization. When the temperature drop was 20° F. or greater, the rise in the freezing point values, due to the removal of dissolved gases, was balanced or exceeded by concentration of milk.

The condensate, or water removed from the milk during pasteurization, was nil for vacuum-pasteurized samples where the temperature drop was less than 20° F. With a temperature drop of 25° F. and greater, the volume of condensate collected showed that concentration of milk occurred and increased in a nonlinear manner as the temperature drop increased.

The results of this study indicate that concentration does not take place in a vacuum pasteurizer of the type used in this work until the temperature drop exceeds 20° F. Water is not removed from the milk when the equipment is operated as the manufacturer suggests. Freezing point values must be corrected for apparent dilution, and total solids values (homogenized milk) for apparent concentration, to yield the same information as measurements of the actual water removed from the milk during processing.

DETERMINATION OF CURD-MAKING QUALITY OF NONFAT DRY MILK

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The cottage cheese industry has used annually millions of pounds of nonfat dry milk (NDM). To produce high-quality curd, the reconstituted cheese-milk must sustain growth of starters, form a gel of sufficient strength for cutting and cooking, and produce curd which will permit proper whey drainage. Several companies, however, reported that some powders produced low yields of soft, poor-quality curd. A firm gel was formed, but it softened and shattered during cooking. Whey expulsion was slow and the curd was soft and wheyed-off during storage. These defects were not indicated by the conventional quality standards for this type of NDM. The purpose of this research was to develop a laboratory method for evaluating the curd-making quality of cottage type dry milk.

In the method developed, curds were made by identical procedures in small, twin laboratory vats, using large amounts of low heat starter. The starter milk was prepared from the same NDM as that used to make the cheese-milk, and was pasteurized at 155° F. for 30 min., cultured at 72° F., and thoroughly mixed into 25 lb. of freshly reconstituted unpasteurized cheese-milk. The setting temperature was 95° F., cutting was at pH 4.7, and the cooking temperature was 120° F.

The finished curds were graded, and the curd-making quality of the unknown NDM was evaluated by comparing its curd with that of the control powder. The

technique pointed out curd-making defects not indicated by the curd tension value or the soluble whey protein content of the powder. Accuracy of the determination was improved by cancellation of curd defects due to defective starters or other causes. The method may be modified by a plant to permit evaluation of NDM by their curd-making procedures.

SOME EVIDENCE SUPPORTING THE SPECIFICITY OF MILK LIPASE FOR THE PRIMARY HYDROXYL POSITIONS OF MILK GLYCERIDES

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A fat molecule consists of glycerol with three fatty acids attached to it. Milk lipase frees these fatty acids to produce a rancid flavor. Dairy chemists have often wondered about the order in which the fatty acids are released from the fat molecule. It is known that pancreatic lipase, the fat-digesting enzyme of the small intestine, releases the two outside fatty acids from the fat molecule. However, this information is not available for milk lipase. Methods are available for estimating the compound which would be left over from the pancreatic lipase type of fat digestion. These compounds, called 2-monoglycerides (a glycerol molecule with a fatty acid in the center or 2-position), would be present in large excess in digested milk fat if milk lipase preferentially releases the two outside fatty acids.

Rancid milk, prepared by mixing raw and homogenized milk in equal portions, was analyzed for 2-monoglycerides over a period of 2 hr. The experiment was repeated five times. The average 2-monoglyceride content was 82.3% of the total monoglycerides, which indicates that milk lipase preferentially releases the two outside fatty acids of the fat molecule.

INHIBITION OF OXIDIZED FLAVOR IN HOMOGENIZED MILK AS RELATED TO THE CONCENTRATION OF COPPER AND PHOSPHOLIPIDS PER UNIT OF FAT GLOBULE SURFACE

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Homogenizing milk inhibits the development of oxidized flavor. For years that has been the best practical method of controlling oxidized flavor in market milk. Why it retards the development of oxidized flavor has not yet been established.

Homogenization subdivides fat globules, thus creating additional fat globule surface. At a homogenization pressure of 3,000 p.s.i.g., the fat globule surface area is increased four to five times. The oxidative reactions that cause oxidized flavor

in milk take place on that surface. The constituents involved are phospholipids and oxygen, catalyzed by copper. The increase in surface area decreases the concentration of phospholipids and the copper per unit of area, and proportionately to homogenization pressure. The inhibition of oxidation by homogenization was found to be related to the extent of the increase in surface area. The amount of copper necessary to add before or after homogenization, to nullify its effect, is also related to the increase in surface area.

The results of this study indicate that the homogenization retards the development of oxidized flavor because it causes the large increase in fat globule surface and the proportional decrease in concentration of phospholipids and copper per unit of the newly formed fat globule surface area.

ACTION OF PANCREATIC LIPASE ON MILK FAT

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For milk fat to maintain a favorable position in the market place of the future, a much better understanding of its structure will be required. A knowledge of structure will aid greatly in establishing the mechanism of fat formation. Such information may afford a basis for methods of inducing the cow to change the composition and structure of milk fat, to meet specific needs for which the particular milk will be used.

Using newer analytical tools and techniques, the structure of the triglycerides of milk fat was investigated. It was found that these triglycerides show a structural pattern different from that reported for most other fats. Of particular interest is that cow depot fat seems to have a different pattern of triglyceride structure than does milk fat. This finding is interpreted to mean that two somewhat different pathways of triglyceride synthesis exist in the bovine.

GENETIC AND PHENOTYPIC RELATIONSHIPS BETWEEN CLINICAL MASTITIS, LABORATORY CRITERIA, AND UDDER HEIGHT

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Most diseases of livestock have been satisfactorily controlled through the use of preventative and therapeutic measures. Mastitis has not been controlled to a satisfactory degree by such means and, therefore, the possibility of breeding for resistance deserves consideration.

Previous estimates of the degree to which mastitis resistance is inherited suggests that the incidence of the disease could be reduced by selecting herd replacements and future sires from the more resistant individuals. In the present

study, an estimate of this nature was made, using a classification scheme which would allow an individual's mastitis resistance to be described more precisely than in prior studies. Additional studies were made of some of the relationships between clinical mastitis, leucocyte count of the milk, bacterial content of the milk, and udder height. Data for these studies were obtained from 682 lactations, completed in four state-owned dairy herds.

The importance of inheritance in mastitis control was determined by comparison of daughters' scores with the scores of their dams, and by comparisons involving cows all sired by the same bull. The results suggest that the fraction of the differences in resistance to clinical mastitis due to inheritance is approximately the same as found for milk and fat yields.

From the study of the relationships between clinical mastitis, leucocyte count, and bacterial content, it was found that the scores for clinical mastitis and leucocyte count were closely related, and were probably controlled in large part by the same genetic factors. Scores for clinical mastitis and for bacterial content were not closely related.

Udder height was determined by measuring the distance from the floor of the udder to the barn floor at 30 to 60 days following calving, and just prior to milking. The udder height was found to be related to scores for clinical mastitis, leucocyte count, and bacterial infection. Udders with low floors were more susceptible to clinical mastitis, and the milk from them contained larger numbers of leucocytes and was more frequently infected with undesirable microorganisms than was milk from more highly attached udders.

EFFECT OF SEVERAL VARIABLES ON IN VITRO RUMEN FERMENTATION

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During the past decade, a considerable amount of investigative effort has been directed toward a more complete understanding of the nutrition and physiology of ruminant animals. A considerable fraction of this research has dealt with the functions of microorganisms in the rumen and their relationship to the host. Since experimentation with large animals is usually slow and expensive, laboratory procedures have been developed with the idea that they may speed progress and still provide information which is reasonably well correlated to live animal performance.

Those procedures dealing with rumen digestion are referred to as in vitro, or artificial, rumen studies. In this procedure, a feedstuff is added to flasks along with a mineral solution, to supply essential minerals and to maintain favorable acidic conditions, and some rumen liquor or juice (strained or centrifuged) to supply a source of the microorganisms which normally inhabit the rumen. This

mixture is fermented at body temperature for some designated period of time and the loss in dry matter, crude fiber, cellulose, or other fractions is determined. In addition, the production of end products such as bacterial proteins, vitamins, or fatty acids may be determined.

In the past, research originating from several experiment stations has indicated a reasonably good correlation between artificial rumen and live animal digestion of various feed fractions of some forages, particularly with respect to crude fiber and TDN. However, most of the laboratories have used procedures which differ from place to place, making comparisons between laboratories difficult if not impossible.

It was the purpose of this investigation to study the effect of several variables on in vitro digestion of various roughages, with the ultimate objective of stimulating the development of more uniform procedures.

Results from the first series of experiments indicate that percentage of cellulose and dry matter digestibility was increased by reducing the quantity of feed (alto fescue) added to the artificial rumen flasks, and that increasing the amount of rumen liquor increased the digestion. Changing the quantity of mineral solution added to each flask had no appreciable effect, however.

In another series of experiments, data indicated that marked differences in digestion may result due to differences in the origin of the rumen liquor added, even when twin steers on the same feed are compared.

The pH level to which the fermentation media was adjusted was shown to have a marked effect on digestion, with indications that some rumen liquors are affected more unfavorably than others.

A comparison between alfalfa and peavine hay showed that cellulose digestion in alfalfa was depressed by fine grinding, but that no effect was observed with peavine hay.

A new and simple method of determining dry matter loss in the artificial rumen was employed throughout most of these experiments. It involves simply filtering a sample through a glass filter and drying in an oven. Dry matter digestion determined in this manner was highly correlated with cellulose digestion. This procedure offers a simple and time-saving method with which to study digestion of feedstuffs in the artificial rumen.

PHYSICAL AND CHEMICAL CHANGES IN BOVINE SALIVA AND RUMEN LIQUID WITH DIFFERENT HAY-GRAIN RATIOS[1,2]

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Saliva is an important buffering agent for the acids produced during ruminal digestion and can also alter the chemical and physical composition of rumen contents through addition of such salivary constituents as urea and mucin. It has been shown that salivation is affected by the feed which, in fact, might explain

the frothy bloat frequently occurring with high-grain rations. This study of two cows fed various proportions of hay and grain constituted a search for changes in saliva or rumen fluid which could be attributed to the grain content of the ration.

The viscosity of saliva increased after feeding and saliva became more alkaline as the proportion of hay increased. The nitrogen and hexosamine content of saliva and rumen fluid was higher when high-grain rations were fed. Hexosamine is a constituent of mucin and could be involved in frothing.

The sodium concentration in the rumen was depressed when high-grain rations were fed. The sodium concentration in the rumen was also higher for the cow which tended to bloat. This difference appeared to be independent of changes in the composition of the saliva.

Although more information is needed, these results suggest that the nitrogenous components of saliva and rumen fluid are involved in the bloat associated with high-grain rations.

SYMPOSIUM: STUDENT ENROLLMENT TRENDS IN AGRICULTURAL COLLEGES

INTRODUCTION

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The Education Committee was established as a special committee of the American Dairy Science Association in 1955. Since that time the committee has investigated many subjects of educational interest. It has also conducted programs at the annual meetings. Because of the importance of material to be considered by the Committee, the Board of Directors in 1958 voted that the Special Committee on Education become a standing committee of the Association. The members of the Committee, consisting of B. L. Herrington, E. L. Jack, H. L. Mitten, R. P. Neidermeier, C. L. Pelissier, G. H. Wise, and J. T. Lazar, Jr. as Chairman, formulated this program for the 54th Annual Meeting at the University of Illinois, and concurred that a discussion be held concerning enrollment problems in colleges and universities. Three outstanding educators were invited to discuss enrollment problems in agriculture, with emphasis on the trends in dairy science. The addresses of the speakers in this symposium are published to stimulate interest and concern for continuing enrollment of students in the dairy science curricula of manufactures and of production.

THE STATUS OF DAIRY MANUFACTURING MAJORS IN THE LAND GRANT COLLEGES OF THE UNITED STATES AND CANADA

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A survey of the colleges in the United States and Canada offering instructional work in the field of dairy manufactures was made in the spring of 1959. Data were obtained from 40 departments in this country and four in Canada. The summarized results follow:

Students Majoring in Dairy Manufacturing

Class	1955	1959	Increase
			(%)
Senior	209	251	20
Junior	172	205	19
Sophomore	130	157	19
Freshman	98	127	30

Data for the sophomore and freshman year are not too significant, since in a number of colleges majors are not declared until the junior year, so that, in some cases, accurate records on registration in dairy manufactures for the first 2 yr. are not available.

The study revealed a number of interesting facts, which are summarized as follows:

(1) The department having the largest number of seniors graduating this year reported 20 candidates for a degree.

(2) There were nine departments reporting ten or more seniors.

(3) There were 22 departments reporting fewer than five seniors, and ten departments had only one senior. One department reported no majors in dairy manufactures.

(4) Approximately 43% of the seniors that graduated this year in dairy manufactures were enrolled in 18% of the universities, and 7% of the departments supplied 20% of the graduates.

(5) Four universities from states that represent about 16% of the population and 30% of the total milk production of this country graduated nearly one-fourth of the seniors majoring in dairy manufactures.

(6) Of the 44 departments reporting, 19 had fewer seniors this year than 4 yr. ago, three had the same number, and 22 showed an increase.

The significance of the results of this survey can be interpreted in a number of ways, depending somewhat upon one's point of view. It is certainly evident, however, that there are too many departments offering specialized training in dairy manufactures. The needs for college graduates in industry are greater today than ever before, but the requirements of those trained in the specialized field of dairy manufactures are of a different nature than they were 30 yr. ago. Since there is no particular shortage of dairy manufacturing graduates, schools with few students registered in this

field probably could be more useful to industry by offering training in the general field of food technology. The country's needs for students trained in the specialized field of dairy manufactures could be easily taken care of by possibly nine departments located, for the most part, in the dairy producing sections and population centers of the country. For example, dairy technology departments in schools located in the following sections would probably be ample for the United States needs for graduates in dairy manufactures:

Southwest—1
Northwest—1
Southeast—1
Northeast—1
South Central—1
North Central—2
East—2

How much longer tax-conscious voters will continue to support the extravagance of maintaining in our colleges departments that serve less than 50 students for the benefit of a single industry may be the determining factor as to how long it will be before college administrators ask that consideration be given to limiting the teaching of dairy manufactures to a certain number of colleges. Obviously, it can not be decided on the basis of the interests of the faculty and of those employers recruiting a cheap labor force with trained minds.

The author has recently completed a study of automation in dairy plants throughout the United States. From this survey it was obvious that the type of training that men should have to operate the highly mechanized and automated dairy plants of tomorrow will be quite different from that considered satisfactory a decade ago. Engineering skills and business management will be of primary importance in the training of tomorrow's food plant operators. Considerable thought should be given to this aspect of the problem in the reconsideration of methods of training leaders for the dairy industry.

ENROLLMENT TRENDS IN DAIRY PRODUCTION

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A questionnaire was sent to 49 states and Hawaii requesting the number of undergraduate students by classes and by years from 1949 through 1958. Information on the numbers of students who received the master's degree or the doctorate degree was requested for the same 10-yr. period. Forty-three states responded.

The intent of the questionnaire was to obtain general enrollment trends of dairy production students. The data obtained would not warrant a thorough and complete analysis. For those students who selected dairy production as their major, it would have been helpful to know the drop-out rates and their reason for changing, etc. Regardless of the number of students who chose dairy production initially, only those who graduated are available to the industry. As dairy departments fulfill their educational obligation to the dairy industry, we hope the B.S. degree, M.S. degree, and Ph.D. degree graduates will make a very real contribution to the future of the dairy industry.

Results of questionnaires

(1) Factors affecting declaration of a major in dairy production.

(a) Institutions which do not offer a separate dairy production major, but whose students interested in dairy are classified as animal husbandry majors: California, Delaware, and Nevada.

(b) Institutions which offer dairy production and dairy manufacturing in the same curriculum: Idaho and South Carolina.

(c) Institutions at which students declare their major in dairy production for their junior year. Florida, Oklahoma, Tennessee, West Virginia, and Wisconsin.

(d) Institutions at which students declare their major for their sophomore year: Louisiana, Maine, Montana, South Dakota, and Rhode Island.

(e) Institutions at which students may or may not declare their major during their freshman and sophomore years, but must do it for the junior year: Illinois, Michigan, and Mississippi.

(f) Institutions which began a dairy production curricula in the last 10 yr.: Arkansas, Colorado, Illinois, and Wyoming.

(2) Dairy production major numbers.

The number of students who have graduated with the B.S. degree (Table 1), the M.S. degree (Table 2), and the Ph.D. degree (Table 3) show interesting trends. B.S. degree graduates have decreased slightly. The number of undergraduates is somewhat larger than shown, since five

TABLE 1
Graduates with Bachelor of Science degree in Dairy Production 1949—1958

Year	No. departments reporting	Graduates No.	Graduates Range
1949	31	269	0–30
1950	31	386	0–28
1951	32	334	0–32
1952	32	315	0–33
1953	32	287	0–30
1954	32	260	0–22
1955	33	251	0–29
1956	34	237	0–23
1957	36	292	0–29
1958	36	259	0–31

TABLE 2
Graduates with Master of Science degree in Dairy Production 1949–1958

Year	No. departments reporting graduates[a]	Total No. graduates
1949	21	65
1950	27	72
1951	24	55
1952	28	67
1953	29	68
1954	26	77
1955	29	80
1956	28	65
1957	32	92
1958	31	88

[a] Departments reporting one or more graduates.

institutions do not offer dairy production majors as such.

Some administrators might raise the following questions: Does the small number of dairy production students warrant the offering of this major? Should courses be offered for these majors? Can the institution afford to offer courses for these majors? Who will supply trained men for the dairy industry? How much training and what kind of training is needed for the leaders of our dairy industry in 1975 or in 2000? It is reasonable that each department should discuss this question thoroughly. Generalized statements for the entire country might be dangerous when applied to certain areas where well-trained men are needed.

The number of Master's degree graduates has increased markedly over the 10 yr. What is the undergraduate major of these Master's degree men? If they are dairy production majors, why is this such a high proportion? Does this mean our B.S. men have difficulty in finding remunerative positions in the industry? Does the Master's degree graduate have a broader and greater opportunity for employment for off-the-farm positions? In my opinion, the answers to the last two questions are "Yes." In addition, many of our B.S. degree graduates can not farm or enter related farm business because of economic

TABLE 3
Ph.D. degrees in dairy production 1948–1959

Year	No. departments reporting graduates[a]	Total No. graduates
1949	7	19
1950	8	18
1951	10	23
1952	11	31
1953	9	25
1954	14	33
1955	11	31
1956	11	25
1957	11	32
1958	13	22

[a] Departments reporting one or more graduates.

reasons, and certainly those who have demonstrated academic proficiency should continue their education.

Doctorate degree graduate numbers are small and variable. Numerous excellent opportunities are available for these graduates. Undoubtedly education, research, and industry will continue to demand more of these students.

Opinions

(1) With the decrease in number of dairy farms, but with the increase in size and complexity of the dairy farm business, more and better trained dairy production men will be required not only as farmers but people who serve these farms.

(2) Businesses related to dairy farms are increasing in size and breadth. Thus, they will require better trained men. Dairy production majors can meet the needs of these positions.

(3) To supply (1) and (2) above, dairy production students should be trained not only in subject matter related to the science and technology of dairying operations but also in the subject matter of business organizational needs, procedures, and financing. Some dairy production curricula need revising in this respect.

(4) The science of dairy production continues to demand men with more knowledge of the basic sciences and disciplines. Students who have the ability and are interested should be encouraged early in their college program to get essential courses. Dairy production curricula should be flexible enough to permit students to take those courses which will prepare them for advanced science courses. Thus, the Doctorate dairy production student will be in a favorably competitive position with men trained in other areas of work.

(5) To meet the demands and needs of the dairy industry, two options should be offered in dairy production. (a) Tech-

nology and business option and (b) science and technology option.

(6) Bachelor's, Master's, and Doctorate degrees should be offered in these two options by dairy departments. Dairy departments must vigorously develop programs for 1960, 1975, and 2000, or others will assume the responsibility.

ENROLLMENT TRENDS IN AGRICULTURAL COLLEGES

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The American Dairy Science Association, and especially its Educational Committee, is to be commended for devoting some serious thought to college enrollment in dairy production, dairy manufacturing, and in agriculture as a whole. You have recognized the existing situation and have demonstrated that you are willing to face the problem squarely, in an effort to find a solution. All of us would agree that nothing is to be gained by looking away from the problem and hoping for an automatic solution through some accidental set of circumstances.

As the current Chairman of the Resident Instruction Section in Agriculture, American Association of Land Grant Colleges and State Universities, I assure you that our organization is vitally concerned with the level of agricultural enrollment. We do not have all of the answers, but we are eagerly attempting to get at least some of them. For instance, the Resident Instruction Section distributed in 1955 for the first time a national publication on careers for college agricultural graduates. This publication, entitled Careers Ahead, has been used rather widely by individuals and groups throughout the country. I've Found My Future in Agriculture is a recent revision of Careers Ahead and it, too, is reaching large numbers of people.

Prior to the preparation of these career publications, our land grant colleges generally had not given serious thought to recruiting agricultural students. We now recognize the fact that we have a definite responsibility in this area. The term recruiting is used in the sense of making information on careers in agriculture available to prospective students, then leaving the final decision to them.

We should at least give prospective students career information comparable with that being given, with a favorable press, by other groups. In this connection, we compliment Chas. Pfizer & Company for doing such an excellent job in preparing the film, Dynamic Careers Through Agriculture. This is a good illustration of how agricultural industry can help the colleges and universities with a problem of mutual interest.

What is the basic problem facing us? Expressing it simply, the colleges of agriculture are not sharing in the increasing total undergraduate enrollment in American universities. This must cause all of us in the colleges of agriculture to consider the situation seriously with respect to both internal and external factors. For instance, have we adjusted our curricula to prepare graduates properly for jobs in the changing field of agriculture? Are students finding that, for some of the jobs in agriculture, they can receive better college preparation in some other discipline?

Total enrollment in the nation's colleges and universities set a new record in 1958-59 for the seventh consecutive year.[1] The total enrollment at the beginning of the academic year was about 3¼ million, which exceeded the corresponding 1957-58 enrollment by 6.2%. In the early 1960's, the colleges will begin to feel the impact of the significant increase in births during the 1940's. It has been estimated that in the next decade the number of young people applying for college enrollment may double.

Data submitted by 64 land grant institutions show that 32,499 undergraduate students were enrolled in agriculture at the beginning of the 1958-59 session.[2] This represents a 2.7% decrease compared with the previous year. Perhaps it would be interesting to review the fall agricultural enrollment data for a few years prior to 1958-59. For example: 1948-49—45,853; 1951-52—34,774; 1956-57—34,528; 1957-58—33,398. These data, therefore, show a continuous decrease in total agricultural enrollment since 1948-49. The 1958-59 enrollment is a decrease of about 29% compared with 1948-49.

Comparing 1958-59 with the previous year, an increase in undergraduate agricultural enrollment was reported in approximately one-half of the land grant institutions, but in most instances the increases were relatively small. Somewhat more encouraging is the fact that about two-thirds of the institutions experienced an increase in freshman enrollment, compared with 1957-58.

The 1958-59 undergraduate enrollment in agriculture at the land grant institutions was 8.0% of the total undergraduate enrollment, compared with 8.5% for 1957-58. In 1948-49, the undergraduate agricultural enrollment represented 11.7% of the total undergraduate enrollment.

[1] *American Council on Education Bulletin*, Volume VII, Numbers 1 and 38, 1958.

[2] *Proceedings of the American Association of Land-Grant Colleges and State Universities*, Seventy-Second Annual Convention, Nov. 10-13, 1958.

The freshman enrollment in agriculture at the land grant institutions is of special interest. In 1958-59 we had 9,416 freshmen compared with 10,515 in 1948-49, a decrease of about 10.5%.

The baccalaureate degree in agriculture was awarded to 7,235 students during 1957-58. This is greater than the 7,005 for the year before, but less than the 8,187 for 1948-49. However, since 1948-49 we have had a significant increase in the number of master's and doctor's degrees awarded in agriculture. Now, let us direct our attention to some factors that should be considered in the analysis of the low enrollment in agriculture.

OUR CHANGING AGRICULTURE

The number of farms in this country has declined from more than 6 million in 1940 to about 4½ million in 1958, and undoubtedly will decline further in the future. While the number of farms was decreasing, the average size of farms was increasing.

The farm population has dropped from over 30 million in 1940 to about 20 million in 1958. All indications are that this, too, will continue to decrease. The farm population now represents only 12% of the total population, compared to 23% in 1940. In political circles, farmers are being considered more and more as a minority group. This situation emphasizes the need for capable farm leadership.

Farmers are becoming more efficient. The productivity per man-hour of farm labor has increased more than 4% per year during the past 10 yr. Today, one farm worker produces enough for himself and 20 others. In 1940, the ratio was 1 : 10.

Vertical integration or contract farming is becoming increasingly popular. This movement calls for skilled management, large-scale financing, and a new role for the farm operator. It presents some serious questions not only for farmers but also for the agricultural colleges.

Modern farming in America is a combination of science, business, and technology, and the capital investment per farm worker is higher than the investment per industrial worker. It will become increasingly important for tomorrow's farmers to have a college education.

Agriculture has undergone many changes in this country and it will continue to change in the years ahead. We are in a dynamic field. The advance of agricultural science and technology has transformed agriculture from what was basically farming into an extremely complex scientific industry. Today's agriculture includes two very important segments in addition to the production of farm products. One of these involves the processing and distributing of farm products. The other provides services and supplies for the farmer. These three segments together employ some 26 million people in the United States. This means that about 40% of all jobs are related to agriculture.

In reviewing these rapid and marked changes in agriculture, one can not help but wonder if we have made the proper adjustments in the agricultural programs at our land grant institutions. Although it is difficult to arrive at an accurate measure, some of these changes in the agricultural scene are without question related to our present enrollment in the colleges of agriculture.

PUBLIC RELATIONS

All of us in agriculture would be willing to admit that the state of our public relations leaves much to be desired. Undoubtedly, there are many explanations for this, and a few will be mentioned. In the first place, many people have erroneously interpreted the declining farm population to mean a decline in the importance of agriculture. Actually, the reverse is true. Fewer people producing more goods certainly is not the mark of a declining industry. However, the public is not very well informed in this area and we must accept some of the responsibility. We must tell them that modern agriculture involves much more than farm production, and that capital is being substituted for human labor in a veritable agricultural revolution. Further, they must be told that agriculture continues to be the basic industry of the nation, the only one absolutely essential for man's existence.

Another reason we are weak in our public relations is the way in which our agricultural surplus problems have been handled and the bad and distorted publicity regarding the costs of and benefits from farm programs.

In the public eye, agricultural graduates are not generally included in the category of scientist. With this misunderstanding, prospective college students interested in science are not likely to select a curriculum in the college of agriculture. Here, we have a major problem in itself.

If the real facts about modern agriculture were fully understood and appreciated by the public, our colleges of agriculture would not experience so much of the strong competition for students from other disciplines on our campuses.

In recognition of the importance of public relations for agriculture, the Division of Agriculture of the Land Grant College Association has established a Public Relations Committee. Dean E. L. Butz of Purdue University is the Committee Chairman.

INFORMATION ON JOB OPPORTUNITIES

At the present time, our best source of information on job opportunities for college agricultural graduates is the publication, I've Found My Future in Agriculture, which was mentioned at the beginning of this discussion. The booklet states that each year we need 15,000 agricultural graduates, and that our land grant institutions

are graduating about 7,000 each year in agriculture—two jobs for each graduate. The 15,000 jobs are in research, industry, business, education, communications, conservation, and services, as well as in farming. It should be emphasized that these are national figures and that this ratio will not be exact for all places and at all times. Likewise, there will always be some students who will find it difficult to get a satisfactory job no matter how great the need.

An extremely important fact to remember is that most of the jobs available to agricultural graduates are in areas other than farming. In this connection, a recent survey of former agricultural students at Clemson College revealed that only 10% of the graduates were farming, whereas 32% were employed in business and industry.

We definitely need more factual information on employment opportunities. We need to know exactly where the jobs are, and also the number of new jobs available each year. Too, we need from the employers more information on the qualifications desired of our graduates. The Resident Instruction Section of the Land Grant College Association is aware of this need for information and, at the present time, has under consideration a proposal for a rather extensive study of the recruitment, education, and placement of agricultural students. Agricultural industries would play an important role in this proposed study. It is important that we, in some way, provide on a national basis current and factual information on employment opportunities for our graduates.

AGRICULTURAL CURRICULA

Many people in our educational institutions and elsewhere feel that the low enrollment in agriculture can be attributed, at least in part, to our slowness in adapting our curricula to today's needs.

When the land grant institutions first offered instruction nearly 100 yr. ago, often there was but a single curriculum in agriculture. The curriculum included all that was considered essential in the training of agricultural students. Through the years, the colleges moved more and more toward specialization. Agriculturists became agronomists, dairy scientists, horticulturists, and so on. The increasing degree of specialization within the institutions was reflected in the agricultural curricula. Specialization is important and necessary, but I would remind you that this can easily be overdone at the undergraduate level.

At the present time there is an unusual amount of interest being devoted to the content and organization of agricultural curricula in our colleges and universities. There is no one simple answer to this problem; however, it is becoming evident that the changes in agricultural curricula will frequently include the following:

(1) More emphasis on the so-called basic sciences. Included in this category are mathematics, biology, chemistry, and physics.

(2) More emphasis on business. Recognition is being given to the extreme importance of business in today's agriculture.

(3) Less emphasis on art or practice. Practices of today may not be followed tomorrow. We can not afford to waste time on aspects of agriculture which have only a temporary application. Perhaps some of the material we are teaching now in our regular college agricultural curricula should be reassigned to short courses.

When discussing curricula, we should never forget that well-qualified faculty members are much more important in the education of our youth than a fancy listing of courses in the college catalog. Undoubtedly, there are additional factors related to our agricultural enrollment. Those mentioned will serve to indicate some of the problems before us.

For the dynamic, complex, scientific industry of agriculture, we need large numbers of capable and highly trained personnel. The low enrollment in our colleges of agriculture today is a tremendous challenge. I feel confident that the agricultural leadership of this nation will accept the challenge.

OUR INDUSTRY TODAY

REAPPRAISAL OF THE QUALITY CONTROL OF MILK SUPPLIES FROM FARM BULK TANKS

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The advent and widespread use of the farm bulk tank for milk supplies have contributed richly to improving the quality of milk available for pasteurization. Any milk inspector or dairy sanitarian can not help being impressed with the dramatic reduction in the standard plate counts of raw milk from farm bulk tanks and the reduction in counts for thermodurie bacteria after laboratory pasteurization.

Without deprecating the value of the contribution which the farm bulk tank has made, it is in order to temper the first blush of enthusiasm with more deliberate analysis of how this important improvement is effected and where it fits into the over-all problem of quality milk.

Eight items are offered for consideration:

(1) It should be recognized that the contribution to the improvement in quality of milk from a farm bulk tank depends largely upon (a) the elimination of the conventional 10-gal. can with its attendant can washer—two pieces of equipment which were frequent sources of trouble, and (b) the prompt cooling of milk to temperatures below 40° F., which is considerably below those thought possible in can-cooling tanks.

(2) The bacterial standards by which any milk operation is judged as acceptable or poor must necessarily be adjusted to the tools and facilities at hand. Shortly after the turn of the century, when it was the accepted practice to cool milk in a stock watering tank or in a spring, standards of a million bacteria per milliliter were about as rigid as could reasonably be enforced. Later, the use of insulated ice water tanks and, still later, the use of electrically operated coolers, as well as the development of better cleaning methods, the construction of better barns and milk houses, made possible progressively more rigid standards of acceptable performance. It has been characteristic of the dairy sanitation program to require producers and dealers to do as good a job in handling dairy products as could reasonably be expected with the tools available at the time, and to judge their performance as acceptable or poor on a basis of standards adjusted to the current situation. The advantages which new tools afford in the handling of dairy products would be lost if the performance were judged by old standards. It is still possible to do a poor job with a farm bulk tank, but the standards used to reveal it may be arithmetically lower than were practical under a can operation. The objective of testing is not to determine how many bacteria there are in the sample but to identify the producer who is doing less than a good job with the tools with which he has to work.

(3) It must be borne in mind that the elimination of the 10-gal. can and the provision for prompt cooling to temperatures below 40° F., important as they are, after all constitute only part of the job of obtaining quality milk. The problems of mastitis, sediment, dirty cows, dirty barns or milk houses, and ineffective cleaning and sanitizing of equipment are still as important as ever. The use of a bulk tank actually has introduced a new cleaning problem, in that the farmer is now responsible for cleaning and sanitizing of the tank.

(4) The advent of the farm bulk tank has, at least temporarily, complicated the job of running sediment tests. The old established procedure of withdrawing a pint sample from the bottom of an unagitated 10-gal. can is not applicable to the farm bulk tank operation. Intensive work is under way to re-establish standards and methods for conducting this important test for milk obtained from a farm bulk tank. Probably some of the sediment in milk came from the cans themselves, especially when stored with loose lids or hauled in a dusty atmosphere; however, it would be unfortunate to conclude that the elimination of the can made the sediment test less important. The sediment test is the one test that every farmer understands, and usually knows what he can do to improve it. Certainly, one of the objectives of dairy sanitation is clean milk, and the loss of the sediment test, even though only temporary, is sacrificing an extremely valuable tool. No other test measures so effectively and impressively the extent to which care has been exercised in protecting the milk against extraneous contamination associated with the barn air and the sides and flanks of the cows. After all, the objective in running a sediment test on milk is not so much to determine specifically how much dirt is in it, as it is to find how much carelessness is in it. Milk produced under conditions which frequently or consistently permit the entrance of excessive

[1] Formerly Director of Research, H. P. Hood and Sons, Boston, Massachusetts.

quantities of extraneous matter reflects a degree of carelessness not in keeping with the way such a food should be handled. Such milk is of poor quality, regardless of how low the bacteria count may be or how low the temperature to which the milk may have been cooled.

(5) Fundamentally, the maximum level of the sanitary quality of milk is determined on the farm where it was produced. Milk obtained from cows with mastitis, or produced in dirty barns or handled by careless people, in poorly washed and sanitized equipment, will always be poor quality, regardless of how promptly it may have been cooled. There is nothing the dealer can do with it, including pasteurization, that will alter the fact that such milk is poor quality and is undesirable. Clarification or filtering of milk is more or less of a standard and, indeed, a desirable practice in milk plants. The removal of the sediment does not alter the fact that if the milk contained excessive sediment, it was produced and handled under undesirable conditions. The place to correct sediment trouble is on the farm and not in the milk plant. Clarification or filtering merely removes the evidence.

(6) There are many tests by which the basic quality of milk may be judged. Each of these tests has its limitations and measures only one or more facets of the total quality picture. Caution must be exercised to interpret the significance of the results from a particular test within those limitations. In certain markets, for example, so much emphasis has been placed on bacteria counts as an index to quality that milk with extremely low counts is regarded as quality milk without further question. To be sure, the bacteria count is a valuable test, but it does not provide a complete picture of the quality of the milk, and is by no means a substitute for inspection. Many undesirable factors which contribute to poor sanitary quality may not be reflected in the bacteria count. The few million bacteria introduced by such things as wet-hand milking, coughing and sneezing into the milk, the presence of a boil on the hands of a milker, dirty barns, dirty cows, and excessive sediment may be lost in the high dilution factor of the volume of milk produced—especially if all of the milk is pooled in a farm bulk tank. If one hundred million bacteria gained entrance through any of the previously named channels, the dilution factor in a 100-gal. pool of milk in a farm bulk tank would arithmetically increase the bacterial content of the milk by only 264 per milliliter—a figure which is well within the limits of error of the counting procedure. Bacteria counts are responsive to the sources of heavy contamination such as poorly washed equiment, badly infected udders and, more particularly, to the factor of growth of microorganisms resulting from slow cooling or poor cooling. Excessively high counts such as several million per milliliter are nearly always associated with ineffective cooling, even though the initial cause may be found in poor washing of equipment or some other source. The exaggerated sensitivity of the bacteria count to the growth factor has frequently introduced confusion into the interpretation of results. Bacteria counts on a producer's milk are so greatly influenced by the rate and ultimate temperature of cooling that they may tend to exaggerate or to conceal insanitary conditions out of proportion to their seriousness. Standards of acceptable performance necessarily have to be set sufficiently high to allow for inevitable growth of organisms commensurate with available cooling facilities.

One of the advantages afforded by prompt cooling of milk to temperatures below 40° F. in a farm bulk tank is that the necessary allowance for the growth factor may be minimized in setting bacteria standards. This should greatly enhance the value of a bacteria count as a more sensitive index to the cleaning methods employed or to the presence of badly infected udders in the herd. The confusion in the interpretation of bacteria counts due to the growth factor is greatly minimized under the conditions of farm bulk tank cooling of milk. It should be kept in mind, however, that the bacteria count on pooled milk is still primarily an index to cleaning methods and in some cases to the presence of badly infected udders.

Cleanliness in the surroundings of the milking operation, with particular emphasis on the contamination from barn air and from the sides and flanks of the cow, is now measured best by the sediment test. The coliform test on raw milk has never met with much favor, because these organisms grew at the temperatures commonly attained in the can cooling of milk and, as a result, the counts obtained were distorted by the growth factor, so that they did not reflect accurately the degree of initial contamination. Under the conditions of prompt cooling of milk in a farm bulk tank to below 40°, the growth factor is minimized and the coliform counts may be expected to reveal more effectively the contamination from barn air, manural sources, and from poorly washed and sanitized equipment.

For many years, a standard of ten coliform organisms per milliliter of raw certified milk has been used. However, such a rigid standard would probably be impractical for market grades of milk produced under somewhat less exacting conditions. At least one state (New Hampshire) is experimenting with an unofficial coliform standard of one hundred per milliliter of market grades of raw milk before pasteurization. It is quite conceivable that the use of coliform counts on raw milk in farm bulk tanks may prove valuable in the future, not only as an index to contamination from poor practices surrounding the milk operation but to poor cleaning and sanitizing of the farm bulk tank.

(7) The basis of quality control of milk supplies is inspection. The function of laboratory testing is to serve as a guide to the inspector or

field man, so as to direct his efforts in the most fruitful channels, where his services are most critically needed. It is rarely if ever possible to stay within the four walls of a laboratory and, on a basis of results from even the most elaborate array of tests, offer more than an intelligent guess as to the sanitary conditions surrounding the production and handling of milk on a farm several miles away. Laboratory tests often reveal conditions which occur when the field man is not there to observe them; however, in many instances the field man does not need supporting evidence of laboratory tests to identify and correct poor methods.

The central objective of sanitary control is to insure milk supplies that are clean, wholesome, and safe. Any test or inspection item that does not have a direct or indirect bearing on this central objective can not be justified on a basis of sanitary control. Each test, to justify the expense and time required, should be designed to identify some deflection from good practices in the production of a clean, wholesome, and safe milk supply. Tests and inspections should not be made juset to determine how good the milk is, but to spot conditions which jeopardize its cleanliness, wholesomeness, or safety. If, out of one hundred tests made on producers' milk, five are found to be in violation of accepted standards, these five analyses are more valuable than the other 95 tests, since they point to the need for corrective measures.

It is questionable if the absolute safety of raw milk as delivered from the farm can be completely assured, even though extraordinary controls such as those surrounding certified milk are employed. It is for this reason that reliance for ultimate safety is placed on pasteurization. Nevertheless, this does not mean that attention should be any less critical of those factors of sanitation such as wet-hand milking, excessive manural pollution (sediment), coughing and sneezing into milk, presence of boils on the body of the milker, poor milking practices, mastitis, abortion, or tuberculosis in the herd, or other possible sources from which pathogenic organisms might gain entrance into the product.

It is far better to employ direct methods designed to identify a specific defect in the proper handling of milk than to rely on some one test, such as the total bacteria count, as the sole index of sanitation. Specific tests for sediment or for mastitis, for example, are far more sensitive and direct measures of the item suspected than the effect such conditions might have on the bacteria count.

(8) One of the important factors in the wholesomeness and acceptability of milk is its flavor. Unfortunately, there are few direct tests by which off-flavors can be detected. It is necessary to depend upon subjective methods which are subject to opinions of individuals with variable sensitivities to taste. The more effective cooling of milk in farm bulk tanks to below 40° F. retards the development of off-flavors which are due to certain microorganisms and to certain enzymes normally present in milk. At the same time, the lower temperatures make it more difficult to detect volatile odors absorbed from the surroundings or from poor feeding practices. Failure to detect off-flavors or odors in a farm bulk tank may result in spoiling an entire tank truck load of milk. One of the most important links in the chain of quality control of milk received in cans was the skilled operator who stood at the front end of the can washer and smelled every can of milk before it was dumped. Good men for this important job were hard to find, but were extremely valuable as the guardian of the quality of milk purchased by the dealer. This man was a direct employee of the dealer and was well aware that the size of his paycheck, and indeed the security of his job, were determined by the effectiveness with which he excluded poor milk. As a company employee, he was fairly well insulated against the wrath of the farmer whose milk he rejected.

In contrast, this very important job of excluding poor milk is now in the hands of the truck operator, who may or may not be skilled or even trained in the art of detecting poor milk. He must face directly the farmer whose whole day's supply of milk (or two days' supply) is being rejected. In addition, if the driver is an independent hauler, he will be sacrificing part of his pay by refusing to haul the farmer's product. This emphasizes the importance of improving the methods of flavor control of milk from farm bulk tanks.

The recent increase in the incidence of rancid milk can not be blamed on the farm bulk tank—in fact, the lower temperatures of milk in the farm bulk tank tend to retard the action of the lipases responsible for the rancid flavor. However, the next logical step for a producer who has installed a farm bulk tank is to consider the purchase of a pipeline milker. Some of these pipeline milkers create conditions which favor the agitation of warm milk and the development of foam, which favors the activation of the lipase enzymes and causes rancidity. Subsequent warming of milk containing the activated enzymes during transportation to the city plant or while awaiting pasteurization may result in the development of a rancid flavor after 24 or 48 hr. of storage in the raw state. Unfortunately, potentially rancid milk may give no evidence of the rancid flavor at the time it is taken from the farm bulk tank. It is good practice to make checks for the presence of fatty acids (water-insoluble acids), on milk received from farms having pipeline milkers, with sufficient frequency to make sure that the particular installation is not one that activates the rancid flavor development.

Some dealers are following the practice of having the truck driver take approximately a half-pint or a pint sample of milk in a paper container each time he collects milk from a farm bulk tank. The paper containers are not

absolutely bacteriologically sterile, but the small residual contamination from them is negligible. These samples may or may not be tested when they are received at the plant, but the producer does not know when or for what they may be tested. On some days the samples may be tested for flavor, on other days for such things as bacteria counts, solids, fat, rancidity (water-insoluble acids), the presence of antibiotics, mastitis, or any other test which will yield valuable information. Such a program of daily sampling and intermittent testing for any one of many tests tends to keep the producers alert to all factors of quality. Such a program is of little or no value unless it includes a follow-up with the producers whose products fail to meet accepted standards of performance.

SUMMARY

It is clearly apparent that the farm bulk tank has provided the dairy industry with a useful new device for improving the quality of milk from farms. Milk as it comes from the normal udder of a healthy cow is at its peak of sanitary quality; anything that will eliminate an important source of contamination and at the same time make possible the prompt and effective cooling to retard growth of inevitable contaminants is indeed a step in the right direction. It is important, however, that the farm bulk tank not be regarded as a panacea for all quality problems, just because it makes lower bacteria counts possible. The advantages which the farm bulk tank affords far outweigh the new problems which it presents; however, it is important that these advantages and new problems be recognized, and that appropriate adjustments be made in the standards and tests for evaluating satisfactory performance.

Any reappraisal of present control procedures would indicate at least four items for consideration:

(a) More emphasis on inspection, especially at milking time, to detect undesirable practices not readily detected by tests.

(b) Continued use of total bacteria counts as a routine procedure, but interpreting the results within the limitations of the things it actually measures. This may be coupled with the use of thermoduric counts as an index to poor cleaning and sanitizing methods.

(c) More emphasis on sediment tests as a valuable index to carelessness in the control of the cleanliness of milk. Consideration may well be given to the development of standards for the coliform test on raw milk as a more sensitive index than the total plate count to cleanliness of the barn air, poor milking conditions, as well as to the cleaning and sanitizing methods employed on the farm bulk tank and the milking machines.

(d) Increased emphasis on flavor and odor problems of milk, with special attention to rancidity.

Essential to the success of any milk dealer is the building of public confidence that the products he is selling are clean, wholesome, and safe. In order to sell good milk, he must buy only good milk. This necessitates a well-integrated program of inspection, supplemented with appropriate testing of the product. With the advent and application of new tools or new methods on the farm, in the plant or in the channels of distribution, it is wise also to apply new thinking. Occasionally, there should be a reappraisal of the whole quality control program, to keep it in proper perspective with progress, and in sharp focus on the ultimate objective of a milk supply that is clean, wholesome, and safe.

STRONTIUM^{90} AND MILK

Considerations on Sr^{90} and the Role of Milk in Our Diet

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In a previous publication (2), pertinent data concerning the significance of Strontium^{90} (Sr^{90}) in milk were assembled and reviewed in as scientific a manner as the limited data allowed. Since that time many comments have reached the authors encouraging them to write a more simplified article, and these have prompted the writing of this article.

The available knowledge on radioactivity in milk and other foods has been increasing rapidly in the past year and for this reason a second review article (1) is appearing simultaneously in this issue of the JOURNAL OF DAIRY SCIENCE. Material for this simplified article has been taken from both of these reviews (1,2), and the documentation and further elaboration of the subjects covered in this article may be found there.

Why Has Milk Received So Much Recent Publicity?

The public has become increasingly aware that milk is a carrier of radioactive materials, of which Sr^{90} probably is the most important. In fact, the publicity over the past several years has led many people to consider that milk is the most important source of radioactivity in their diet, causing Sr^{90} to deposit in their bones. As shall be discussed later, actually many common foods, notably from plant sources, are biologically more important sources of Sr^{90} than is milk. It is necessary to understand why

milk received the publicity it has as a source of radioactivity. This may be attributed to two major reasons: (a) Milk samples are readily available at all times of the year in all sections of our country; no other food is as universally produced or consumed. Thus, most testing has been conducted on milk and, consequently, most of the data reported has concerned milk. Unfortunately, this initial attention to milk has generated public pressure to survey more milk and this has hampered efforts to define the Sr^{90} problem in relation to other foods. (b) Sr^{90} is chemically and biologically quite similar to calcium and generally is found along with calcium in foods. The American public receives about 85% of its dietary calcium from dairy products and, therefore, they were examined for Sr^{90}. However, the cow removes most of the Sr^{90} from feedstuffs in making milk; thus, milk has a high ratio of calcium to Sr^{90}. In the animal body, the bone deposition power of Sr^{90} in the diet is dependent on the ratio of it to calcium, not on the absolute amount of Sr^{90} present. Sr^{90} can exert less effect if it is consumed with large amounts of calcium. It has been the lack of understanding of this latter important concept, coupled with the initial attention to milk, that has made milk appear to the public as the principal (and in many cases the only) item of their food supply leading to radioactivity in their bodies.

Where Does Strontium^{90} Come From and How Does It Enter Our Food Supply?

The fallout of radioactive materials has resulted primarily from the earlier explosions of the atomic bomb and the more recent explosions of the hydrogen bomb. The hydrogen bomb itself produces chiefly tritium, a weakly radioactive form of hydrogen. However, an atomic bomb is required at present to detonate the hydrogen bomb and it is the fission of uranium in the atomic bomb that produces the most important biologically harmful radioactive materials. Recent evidence has indicated that blasts set off several hundred miles away from the earth's surface or placed underground may cause little or no fallout. These ways of testing, coupled with the possibility of developing a hydrogen bomb that does not need an atomic bomb for detonation, indicate that means are being developed for reducing or eliminating earth-surface fallout without hindering the development of atomic energy development.

Depending on the size of the nuclear blast, radioactive fission products may be thrown high into the stratosphere, where the fallout back to the earth takes years to occur, or thrown not so high, into the troposphere, where the fallout time is only a few weeks. Many radioactive elements are produced in an atomic blast and all of them contribute to the total radiation just after the detonation. However, in considering the long-term situation, most of these are either short-lived (they decay rapidly to nonradioactive elements) or are not taken up by living matter, where they might exert a greater harmful effect. There are several notable radioactive elements which are exceptions to this and these are the ones of concern in long-term, low-level radiation. The one of primary concern in milk and other foods is Sr^{90}, an isotope which eventually decays to a harmless element but takes 28 yr. for one-half of any given amount to decay. It is during the decay process that radioactive particles are released.

The Sr^{90} formed in the fission reaction is blown into the atmosphere, becomes distributed by the winds, and gradually settles on to the earth's surface. Most of the atomic blasts have occurred in the Northern Hemisphere and most of the fallout from them has occurred in the same hemisphere, with a maximum in the temperate latitudes.

The Sr^{90} deposited on earth either is washed into the soil or remains on vegetation which may be eaten by animals. That which is washed off is bound to the soil similarly to calcium and is retained chiefly in the top few inches, where it is available to short-rooted plants. When plants are eaten by animals, a portion of the Sr^{90} is absorbed into the blood stream and some of it is deposited rather permanently along with calcium in bone, though at a somewhat slower rate than calcium. Some of the Sr^{90} is also passed from the blood stream into a developing fetus and into milk.

How Do We Naturally Defend Against Stontium^{90} in Our Food Supply?

Even though Sr^{90} is chemically and biologically quite similar to calcium, living systems prefer to use calcium and, hence, discriminate against Sr^{90}. For example, some plants discriminate against Sr^{90} by absorbing it from the soil more slowly than calcium. However, soils in some areas of the world are deficient in calcium and others apparently have lower calcium availability, even though the same amount of calcium may be present. As a result, more Sr^{90} is absorbed by plants from such soils.

Once Sr^{90} enters the animal body, it may be discriminated against by the gut, kidney, the placenta, or the mammary gland. The discrimination at each of these sites is approximately 0.5 (also expressed as two). This means that the Sr^{90} is screened out so that the ratio of Sr^{90} to calcium is reduced to approximately one-half as a result of the action at each of these places. Thus, the cow producing milk from feed containing Sr^{90} has discriminated against the Sr^{90} at three sites, and has present in the milk about one-eighth as much Sr^{90} per unit of calcium as was present in its food. In the human body, only about one-quarter to one-half of the Sr^{90} present per unit of calcium is available for deposition in the bones, due to discrimination by the gut and the kidneys.

If calcium is deficient in the food supply, then accordingly, more total Sr^{90} will pass each

discrimination site. Thus, the presence of an adequate level of calcium in the human diet, which is true in general for the milk-consuming nations, means that even though more Sr^{90} may be present in the food, actually less will be ultimately available in the blood stream for deposition in the bone.

Why Can Strontium^{90} Be Dangerous in Our Food Supply?

Radiation from Sr^{90} in the food supply contributes to the total radiation received by the soft tissues within our bodies. However, compared to the radiation received from other natural and man-made sources it is but a negligible contributor. The potential danger from Sr^{90} radiation arises because it can stay in the bone, where its effect becomes cumulative.

The Sr^{90} which eventually becomes deposited in the body, primarily at the active sites of bone growth, remains rather permanently deposited at these sites. This is where the greatest potential danger from Sr^{90} radiation can occur, since the bone is a site of active growth and cell-division (red blood cells are formed chiefly in the bone). The postulated results of such deposition include radiation-induced bone and blood cell cancers, such as leukemia. As a source of radiation causing mutations in the reproductive system, however, Sr^{90} derived from food and deposited in the bones is of little or no consequence, because of the low level present in the tissues at any time and the short penetrating power of the particles freed in the radioactive disintegration process.

In addition to Sr^{90} in our food supply, other radioactive elements also are present. These include $Radium^{226}$, $Iodine^{131}$, $Barium^{140}$, $Strontium^{89}$, $Potassium^{40}$, and $Cesium^{137}$. $Cesium^{137}$, for example, is also produced in a uranium fission reaction and takes a long time to decay, like Sr^{90}. It enters the human body by way of the food supply but, fortunately, the turnover within the body is rapid and, consequently, it does not accumulate appreciably at any site.

$Iodine^{131}$ is more important in the short-term situation immediately following an atomic detonation, or following a nuclear reactor incident such as happened at Windscale in England. When consumed, it concentrates in the thyroid gland, where a high level may induce cancer. $Iodine^{131}$ decays rapidly, however, and after a few weeks food only contaminated with it may be safely consumed. Sr^{89} and Ba^{140} produced in atomic fission also decay rapidly and thus are important only in the short-term situation. $Potassium^{40}$ is and has always been present as a natural part of all normal potassium. It accounts quantitatively for almost all of the natural radioactivity present in food and is present in all living tissues. It does not concentrate at any potentially dangerous location within the body. On the other hand, $Radium^{226}$, from natural sources, does deposit rather permanently in the bone. It is interesting to note that for decades many people in several areas of the country have been drinking water which contains high levels of radium and have deposited in their bones a level of radioactivity many times higher than the present or projected levels coming from Sr^{90} fallout. Thus, in considering fallout from atomic fission testing, only Sr^{90} is of little concern in the short-term situation. In the long-term situation, it is of primary concern and, hence, most attention is focused on it. It is important to recognize, however, that the potential problem with Sr^{90} is relative to possible bone cancer and not to genetic effects.

The previous report (2) discussed in some detail the radiation problem from a quantitative standpoint, in comparing natural and medical sources, with that received from atomic bomb fallout. Various moral and ethical considerations also were discussed. The chief debate among authorities arises from the lack of definitive data on the effects of long-term, low-level radiation on the human body. For example, it is not known whether radiation effects observed at high dosage levels can be extrapolated to low levels or whether a threshold level must be reached before any effects occur. Compared to the radiation received from natural sources such as cosmic rays, ground rocks, and natural variations from radium, etc. in our food and water supply, radiation from Sr^{90} is but a small proportion. It is small compared to radiation received from medically accepted procedures such as x-rays. At the present time, a person will receive more radiation in the bones by living in a brick house or at an increased altitude (like Denver at 5,000 ft.) than from Sr^{90} received in the diet.

The evidence at hand suggests that the additional radiation arising from Sr^{90} in our food supply should not cause us concern now or in the future until the problem of the potential danger of long-term, low-level radiation has been clarified. Certainly, with insufficient evidence to judge accurately, an attempt to keep to a minimum the levels of radioisotopes such as Sr^{90} in our bodies is a wise course of action. In this regard, the available evidence indicates that the consumption of milk, with its inherent high calcium level, is one of the ways to accomplish this. An increasing level of Sr^{90} in milk should not cause us alarm at the present time. All predictions indicate that the level will continue to increase until it all falls out of the atmosphere or, if testing of atomic devices continues, until the new Sr^{90} blown into the atmosphere reaches an equilibrium with that falling out. The food of the cow is primarily from plant sources and as the level in milk increases so will the level in the other foods that humans consume.

How Does Milk Compare with Other Foods?

The average person in the United States received over 80% of his dietary calcium from

milk and about 10% from plant sources (cereals, fruits, vegetables, nuts, etc.). Other foods such as meats, fish, eggs, etc. contribute only about 5% of the average calcium intake; thus, their Sr^{90} contribution can be ignored in most calculations. In general, the levels of Sr^{90} in meats, fish, eggs, etc. are lower than those of the plant sources in our diet and are more comparable to those of milk. Since the amount of Sr^{90} deposited in bone is dependent on the level of calcium present, Sr^{90} contents are often expressed in relation to calcium, although they may be expressed as so much Sr^{90} per unit weight or volume. The ratio of Sr^{90} to calcium in a food or in bone (micromicrocuries of Sr^{90} per gram of calcium) is commonly expressed as the Strontium Unit, or S.U. (previously called the Sunshine Unit). The permissible maximum level in human bone at present has been set at 100 S.U. It should be noted that this permissible level of 100 S.U. is actually less than one-hundredth the level of Sr^{90} in the bone that might produce cancer in some individuals.

The 1958 levels of Sr^{90} in milk range between 3 and 30 S.U., with an average of about 8; 1959 levels probably average around 10 S.U. Plant foods show considerably greater variations than milk and contain several times as many strontium units as milk. It is not known with a confident degree of certainty what the current levels of Sr^{90} are in the foods that we consume other than milk. Since plant foods contribute about 10% of our calcium intake, and if they contain a level of strontium units about ten times that of milk, we receive as much Sr^{90} from them as we do from milk. A summary of the data released up to 1957 indicated that the average level of strontium units in plant sources for human consumption was two to three times that of milk, but with an increasing tendency during the period. More recent data have indicated that the average level is rising rapidly and is now much higher. For example, the average strontium units in the 1958 wheat crop from nine states (Illinois, Kansas, Michigan, Minnesota, Montana, New York, North Dakota, Oklahoma, and Texas) was about six to 30 times greater than the level present in milk produced in these states. The strontium units in plant crops grown in the Animas River Valley of Colorado and New Mexico averaged over forty times greater than milk produced in that area.

One of the reasons why the levels of Sr^{90} in plant foods consumed by humans are continually increasing over the level found in milk is that Sr^{90} is building up in the soil. More Sr^{90} is becoming incorporated internally by the plant, with proportionately less of the total being present as fallout on the surface. Thus, the strontium units in plant foods consumed by humans, even though they may be washed and processed to remove surface fallout before consumption, are approaching the levels found in animal plant foods. The cow discriminates against the Sr^{90} in plant foods by a factor of about eight in making milk, but since cows are also fed calcium supplements containing little or no Sr^{90}, the level of strontium units in milk is actually ten to 20 times smaller than that present in the plant foods the cow consumes. It should be possible to increase this ratio by adjusting the diet of the dairy cow to give further discrimination.

Considerations of the Role of Milk in the Diet in Relation to Sr^{90}

Recent evidence has indicated that peoples receiving their calcium primarily from plant sources are accumulating relatively more Sr^{90} in their bones than those receiving their dietary calcium primarily from milk sources. Peoples of the rice-eating areas have bone levels of Sr^{90} higher than those in any other major area. Sr^{90} also has not fallen uniformly over the earth's surface, as evidenced by the fact that the United States has received three to 15 times more fallout than any other country that has been monitored. Analyses of the Sr^{90} levels in bones from peoples living in the lower fallout areas near the equator and in the Southern Hemisphere have indicated that they have almost as high a level of Sr^{90} in their bones as people in the United States. In general, peoples in the low fallout regions of the world obtain their dietary calcium primarily from plant sources, whereas in the United States and most other Western nations of the Northern Hemisphere, it is obtained primarily from milk and milk products. Calculations have been made to project future human bone levels of Sr^{90}; it is significant that the lowest projected levels are for the milk-consuming nations of the Northern Hemisphere.

Thus, enough data have now accumulated to suggest that the high calcium level in milk has been acting as a protective agent against the high level of strontium units present in the plant portion of the diet. If, for example, the diets of people in the United States were similar to the diets consumed in the lower fallout areas, they would probably have a much higher level of strontium units in their diets and in their bones. Even so, it is necessary to be interested in reducing the strontium units in the diet to the lowest possible level. Several means for accomplishing this have been suggested, which include the lowering of the proportion of milk in the diet and the removal of Sr^{90} from milk. The relative merits of such suggestions are so completely dependent on the ratio of strontium units in the plant portion of the diet to the strontium units present in the milk portion (hereafter referred to as the Plant/Milk, or P/M ratio) that a further discussion of it is in order. If the Plant/Milk ratio is greater than one, the inclusion of milk in the diet will lower the total level of strontium units present. Since the P/M ratio is greater than one, one can not lower the strontium units in the diet if the milk intake is reduced but, rather, the converse is true, i.e., the strontium units in the

diet can be reduced if more milk is included. It is not known definitely how much greater than one the P/M ratio is, though the limited data available suggest that the average P/M ratio is now probably in the range of five to 20 for the United States and much higher for some other areas.

For example, if the P/M ratio is ten, a person consuming a normal diet has in it 1.9 times as many strontium units as there are in milk; on a diet containing one-half the normal amount of milk there would be 2.9 times as many units present, and on a diet containing no milk there would be up to ten times as many units present.

A reduction of the strontium units in the diet equivalent to the removal of the Sr^{90} from milk can be accomplished by adding rock-source calcium to the diet. However, the level of strontium units in the diet can be reduced just as effectively by increasing milk consumption. For example, at P/M ratios of ten and 15, doubling milk consumption is just as effective as removing 60 and 100%, respectively, of the Sr^{90} from milk. The further significance of these calculations can be seen in Figure 2 of the second review article, appearing in this issue of the JOURNAL (1).

The feasibility of increasing rock-source calcium consumption is questionable, since any greatly increased population intake of calcium may lead to greater medical problems from calcium deposits within the body than are associated with the potential cancer hazard. However, a small increase in calcium intake may not be harmful and a greatly increased calcium consumption may be appropriate for short periods of time, such as during pregnancy or in periods of large amounts of fallout as may occur following an atomic attack.

The suggestion of increasing milk consumption likewise can not be taken at face value, since there are some limited data to indicate that as the milk portion of the diet is increased, the discrimination by the human gut against Sr^{90} decreases, due to the presence of lactose in milk. The reader is referred to the articles (1, 2) for further discussion of this point. It will suffice here to say that the average pint of milk or milk product equivalent consumed per day by people of the United States probably does not lower the discrimination by the gut against Sr^{90}. If further work shows that an increased consumption of milk and milk products containing lactose does lower the discrimination by the human gut, then an increase in milk intake probably could be accomplished by consuming such products as cheese from which lactose has been removed.

The dire need for further research, to evaluate the position of milk relative to Sr^{90} in our diet, is apparent. Only by accurately determining the P/M ratio and settling the question of the role of milk and specific milk products in the discrimination by the human gut, can the real role of milk be evaluated; then, intelligent decisions can be made on how to reduce our strontium unit intake and resultant bone deposition level.

DISCUSSION

As the facts concerning the deposition of Sr^{90} in human bones become available, the data are indicating that peoples who receive their calcium primarily from milk are accumulating relatively lower levels than those who receive their calcium primarily from vegetable and cereal sources. The available data suggest that it may be just as efficient to increase milk consumption as a means of lowering Sr^{90} deposition in our bones as to remove Sr^{90} from milk by costly processing procedures which would tend to increase the price of milk and thereby discourage its consumption.

In view of this evidence, it has been disheartening to the authors to have intelligent people, who have based their opinions on what they have been reading in the press the past few years, consider milk the chief source of radioactivity in their food supply and ask if they should decrease their milk consumption or stop consuming milk altogether, especially when they are in high fallout areas. This situation has been prompted by the fact that milk has been so widely used as an index of Sr^{90} level in the diet, with a corresponding lack of proper interpretation and understanding of the role of milk in the diet. Recently, there has been a tendency to report data on Sr^{90} in terms of the absolute amount present per unit weight or volume. For example, let us assume milk and potatoes each contain the same amount of Sr^{90} and are reported as containing 40 $\mu\mu$c. per liter and 40 $\mu\mu$c. per kilogram, respectively (a liter is about the same as a quart and weighs about 2 lb., which is about a kilogram). This amount of each food alone consumed per day would constitute 23% of the permissible daily intake of 176 $\mu\mu$c. of Sr^{90}. However, a person consuming only milk would be accumulating a level of 10-20 S.U. in his bones or 10-20% of the permissible bone level of 100 S.U.; whereas, a person consuming only potatoes would be accumulating 100 S.U. in his bones, or 100% of the permissible bone level. On a diet of equal amounts of milk and potatoes, the person still would be taking in 40 $\mu\mu$c., or 23% of the permissible intake level, but now this diet would be leading to a bone level of only about 20 S.U., or 20% of the permissible bone level. In this latter case of equal amounts, milk is contributing 50% of the Sr^{90} to this diet. The point is that a person could cut his daily Sr^{90} intake in half by eliminating milk from his diet of milk and potatoes, but he would be increasing the amount of Sr^{90} depositing in his bones fivefold. Thus, comparing foods on their total Sr^{90} content is valid only as long as the calcium level is considered simultaneously. Unfortunately, the American public has been led to believe it is the milk in their diet that is causing Sr^{90} to deposit in their bones, and milk

is the first thing they think of removing from their diet when told to reduce their Sr^{90} intake.

It is apparent that as the amount of Sr^{90} present in other foods increases, the evaluation of Sr^{90} levels in the other foods consumed by humans is just as important as the evaluation of the levels in milk. There has been an obvious lack of such analyses. Such data on other foods have not been collected or released with the scope or the frequency covering the current situation with which milk data have been reported. Several agencies are now starting to accumulate such data, and it is hoped that they will be available soon.

There is much additional information that needs to be gathered and many more research problems to be solved before the true role of milk in the diet can be evaluated. It was pointed out in the previous review (2) that people interested in milk should accept a responsibility in finding out facts about Sr^{90} in the areas pertinent to milk, rather than let government agencies do the job and then be disappointed when they report incomplete studies in a manner that has made the public wary of milk. The favorable role of milk in reducing the strontium unit intake in the diet could have been predicted several years ago, had there been an effort to find out such information, and the unfavorable position milk has been put in by the public probably could have been averted.

These comments should not be interpreted as a criticism of the government agencies that have been conducting work in this area of recent date, chiefly the United States Public Health Service. The present surveillance programs have been of a fact-finding nature, prompted by the realization that an important potential problem exists, but recognizing that the levels of these radionuclides in foods are now at quite low levels. The agencies involved should be complimented on this approach, since these data are necessary for making future decisions on the question of whether atomic testing should continue, the types of safeguards needed in using atomic energy for peaceful use, and the procedures to follow in case of nuclear attack, etc. Unfortunately, the public has misconstrued the real purpose of the present studies in assuming that the real danger is with us now. It would appear that the United States Public Health Service has been hindered in its search for information on other foods by undue public pressure to survey more milk, and has been obligated to release data on it at too frequent intervals. It is difficult to properly assess such frequently released data when the purpose of gathering it in the first place was to gain facts so that future data could be interpreted properly.

On the other hand, by definition, government agencies set up for control purposes have difficulty in doing basic research. Primarily, this should be a responsibility of universities, private enterprise, and other sources of basic research.

Thus, the paradox exists that the American public has become and is still becoming wary of milk because milk has received the most publicity as a carrier of Sr^{90}, and yet the available data are beginning to indicate that the consumption of milk in this country has prevented higher levels of Sr^{90} from accumulating in our bones. The need to accurately define the position of milk in the Sr^{90} problem is apparent.

CONCLUSION

The levels of radionuclides formed in test atomic detonations that have entered our food supply are probably of such minor magnitudes that we should not be concerned. Unfortunately, this will not be known conclusively until further facts are known about the effects of long-term, low-level radiation. The present knowledge suggests that the advantages gained from the uses of atomic energy far outweigh even the most speculative harmful effects that could occur.

Even so, the safest course to follow is that of trying to keep to a minimum our intake from food of radionuclides, of which Sr^{90} is probably the most important. Milk plays a very important part in this attempt, and the current situation on milk in the Sr^{90} problem may be summarized as follows:

Facts are now beginning to accumulate which indicate that the consumption of a high calcium level from milk by people in the United States has prevented them from accumulating higher levels of Sr^{90} in their bones. Instead of allowing milk to be further criticized as a carrier of Sr^{90} without proper interpretation of its role in the diet, the public needs to be informed of the role of milk in the diet, lest they become further wary of milk.

There are not enough facts known about the most effective manner of reducing the level of Sr^{90} depositing in human bones. Depending on how high the levels of Sr^{90} are in other foods in the diet relative to milk, the removal of Sr^{90} from milk may not be as effective as adding some calcium to the diet or actually increasing milk consumption. There is a great need for immediate research in this area.

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(Chairman in Extension)

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H. A. HERMAN, National Association of Artificial Breeders, Columbia, Missouri (1962)

EXTENSION

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TYPE

(Chairman Alternates from Production in 1960)

PRODUCTION

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E. C. MEYER, Chairman, Ft. Atkinson, Wisconsin (1961)
I. D. PORTERFIELD, West Virginia State University, Morgantown (1962)

EXTENSION

C. K. CHAPPELL, University of Tennessee, Knoxville (1960)
J. C. THOMPSON, Purina Mills, St. Louis, Missouri (1961)
RALPH WAYNE, University of Minnesota, St. Paul (1962)

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(Chairman Alternates from Extension in 1960)

PRODUCTION

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W. D. POUNDEN, Ohio Agricultural Experiment Station, Wooster (1962)

EXTENSION

H. P. EWALT, Chairman, Oregon State College, Corvallis (1960)
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4-H CLUB

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ANNOUNCEMENT OF THE GRADUATE STUDENT AWARD PROGRAMS

W. W. SNYDER, Chairman,
Student Affiliate Committee
Department of Dairy, Michigan State
University, East Lansing

Two Graduate Student Scientific Paper Presentation Award programs will be sponsored at the 1960 annual meetings:

A. The Production Section Award Program
B. The Manufacturing Section Award Program

Procedure for entering the competition:

(1) Only one graduate student representing a college or university may enter the Production Award program. Another graduate student from the same college or university may enter the Manufacturing Award program. If two or more graduate students representing the same college or university are interested in entering the same award program, the Chairman of that Dairy Department should recommend the one to enter the competition.

(2) To enter the competition, the graduate student who is also a student affiliate member of the American Dairy Science Association shall declare his intention in a letter postmarked on or before February 25, 1960. The letter shall be countersigned by the graduate student's major professor and the chairman of his department.

(3) This letter shall be accompanied by the title of the paper and copies of the abstract of the paper as specified in the Call for Papers for the 1960 Annual Meeting and published in the JOURNAL OF DAIRY SCIENCE, page 1734, for October, 1959.

(4) A copy of the original letter and four additional copies of the abstract shall be mailed to:

A. For Production Section Award
Dr. J. E. Johnston
Dairy Department
Louisiana State University
Baton Rouge 3, Louisiana

B. For Manufacturing Section Award
Dr. W. F. Shipe
Department of Dairy Industry
Cornell University
Ithaca, New York

(5) The rules for these awards will be mailed to the Chairman of each Dairy Department. Additional copies may be obtained from the Chairman of the Student Affiliate Committee.

WELCOME TO MEMBERS OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

Dear President Fay:

It was our privilege to invite the American Dairy Science Association to hold its 55th annual meeting June 19-22, 1960, on our Utah State University campus at Logan. We were honored when you accepted our invitation and now with great pleasure we look forward to welcoming your members, their friends, and guests to Utah State.

Daryl Chase

Special University committees are working to supply your needs and hope that you, your families and guests will enjoy your stay in Logan and Utah.

Utah is the scenic center of the West. If we can help any of you plan your trip to or from Logan, don't fail to call on us.

Let us help you make the A.D.S.A. Conference successful and your Utah vacation one you will not soon forget.

Our University facilities and staff are at your service. We shall look forward to making new friends and greeting our old ones.

WELCOME TO UTAH.

Yours sincerely,

DARYL CHASE
President, Utah
State University

PROGRAM
ANNUAL MEETING OF SOUTHERN DIVISION OF THE AMERICAN DAIRY SCIENCE ASSOCIATION
BIRMINGHAM, ALABAMA
February 1–3, 1960

Monday A.M.

DAIRY PRODUCTION
Presiding: J. T. MILES
8:30–10:45 A.M.
French Room, Bankhead Hotel

Some effects of tranquilizers in dairy cattle, J. M. BUCKALEW, Mississippi State University.

A preliminary report on the use of tranquilizers in connection with electroejaculation of dairy bulls, W. N. PHILPOT, S. D. MUSGRAVE, E. W. JONES, AND W. E. BROCK, Oklahoma Agricultural Experiment Station.

The influence of certain milk and egg yolk–citrate extenders on the motility of bovine spermatozoa stored at 5° C. and −79° C., W. GRANA AND O. T. STALLCUP, University of Arkansas.

The role of cervicovaginal mucus in the preservation of bovine spermatozoa, W. E. MOSS AND DURWARD OLDS, Kentucky Agricultural Experiment Station.

Reconstituted buttermilk as an extender for frozen bovine semen storage, R. M. MYERS, N. PATI, AND L. C. ULBERG, North Carolina Agricultural Experiment Station.

Optimum concentration of reconstituted buttermilk as an extender for bovine semen, N. PATI, St. Augustine's College.

Role of pregastric esterase in the hydrolysis of milk fat in the abomasum of young calves, H. A. RAMSEY AND J. W. YOUNG, North Carolina State College.

Comparison of different levels of protein in a milk replacer for young dairy calves, L. J. BUSH AND J. D. SCHUH, Oklahoma Agricultural Experiment Station.

11:00 A.M. to 12:30 P.M.
General Session

Monday P.M.

DAIRY PRODUCTION
Presiding: H. D. ELLZEY
1:30–4:30 P.M.
French Room, Bankhead Hotel

The resistance of Vibrio fetus to erythromycin lactobionate in semen stored at 5° C., M. E. WELLS, S. D. MUSGRAVE, AND E. W. JONES, Oklahoma Agricultural Experiment Station.

The effectiveness of streptomycin in controlling Vibrio fetus in stored semen, M. E. WELLS, S. D. MUSGRAVE, AND E. W. JONES, Oklahoma Agricultural Experiment Station.

Differential effect of season on conception rate in Holstein and Jersey cattle, JOEL M. HILLIN AND I. W. RUPEL, A & M College of Texas.

Seasonal fluctuations in reproductive efficiency of dairy cows, H. A. POSTON, R. M. MYERS, AND L. C. ULBERG, North Carolina Agricultural Experiment Station.

Evaluating dairy sires of three breeds at different levels of herd production, V. L. BALDWIN AND N. R. THOMPSON, Virginia Polytechnic Institute.

The effect of different rations fed in the dry period upon the next lactation, E. W. SWANSON AND S. A. HINTON, University of Tennessee.

Factors for extending incomplete lactations of Jersey and Sindhi-Jersey cows, J. L. FLETCHER, Iberia Livestock Experiment Station.

Lactation response of dairy cows grazing certain annual and perennial grasses in Alabama. I. Coastal Bermuda, Pensacola, Bahia, Dallis, and Gahi I Millet, G. H. ROLLINS AND C. S. HOVELAND, Alabama Polytechnic Institute.

Lactation response of dairy cows grazing certain annual and perennial grasses in Alabama. II. Tall fescue, oats, and wheat, G. H. ROLLINS AND C. S. HOVELAND, Alabama Polytechnic Institute.

Alfalfa grazing and its contribution to pasture mixtures for dairy cows, W. R. MURLEY, W. B. GILBERT, H. D. GROSS, AND M. L. SELF (Piedmont Research Station), North Carolina Agricultural Experiment Station.

Monday A.M.

DAIRY MANUFACTURING
Presiding: T. R. FREEMAN
8:30–10:45 A.M.
Green Room, Bankhead Hotel

Determining protein in milk by the steam distillation method of Kofranyi, C. VANDERZANT, M. A. BROWN, AND I. W. RUPEL, Texas Agricultural Experiment Station.

A rapid method for determination of milk protein, W. K. STONE, L. F. CREMERS, AND

N. R. THOMPSON, Virginia Agricultural Experiment Station.

A colorimetric method for determining protein in milk with Buffalo Black, C. VANDERZANT AND W. R. TENNISON, Texas Agricultural Experiment Station.

De Laval ultra-high temperature pasteurizer, T. B. HARRISON, University of Tennessee.

Symbiosis in lactic cultures, H. C. OLSON, Oklahoma State University.

Low-calcium media for control of bacteriophage in lactic cultures, H. C. OLSON, Oklahoma State University.

11:00 A.M. to 12:30 P.M.
General Session, ASAW

Monday P.M.

DAIRY MANUFACTURING
Presiding: W. W. OVERCAST
1:30–4:30 P.M.
Green Room, Bankhead Hotel

Some studies of the free-fat acidities of milk, W. W. OVERCAST, J. D. SKEAN, AND DOUGLAS H. STAMPER, University of Tennessee.

The influence on pasteurized milk flavor of rancid milk in the raw supply, A. V. MOORE, A & M College of Texas.

Flavor problems in rearranged milk fat, J. B. MICKLE, Oklahoma State University.

The influence of sugars upon lipolysis in milk, B. J. DEMOTT, University of Tennessee.

Phosphatase reactivation in pasteurized milk, J. B. MICKLE, R. DIAB, AND H. C. OLSON, Oklahoma State University.

Influence of rate of cooling upon the development of hydrolytic rancidity or increase in free fatty acid degree, E. R. JARMAN, K. L. NEELEY, A. V. MOORE, AND J. J. WILLINGHAM, Texas Agricultural Experiment Station and Texas Technological College.

Sanitary aspects of welded lines in milk processing, H. C. OLSON AND J. B. MICKLE, Oklahoma State University.

Tuesday A.M.

JOINT SESSION
DAIRY PRODUCTION AND DAIRY MANUFACTURING
Presiding: J. T. MILES
8:30–10:00 A.M.
French Room, Bankhead Hotel

Theme—The role of manufacturing milk in the South

Moderator—GEORGE HYATT

Panel—The status of manufacturing milk in the South, J. C. FLAKE

A look at the manufacturing industry. Part II. Reasons for the current trends in the situation, M. F. ELLMORE

Advantages of manufacturing milk to Southern agriculture, G. M. BASTIN

Making a business of manufacturing milk production, G. S. PARSONS

Research and educational work on manufacturing milk production in the South, GEORGE HYATT

10:00–11:00 A.M.
Sectional Business Meeting—French Room, Bankhead Hotel

11:00–12:30 P.M.
General Session ASAW

Tuesday P.M.

DAIRY PRODUCTION
Presiding: W. E. THOMAS
1:30–4:30 P.M.
French Room, Bankhead Hotel

Intake and digestibility of coastal Bermuda grass, G. E. HAWKINS AND G. H. ROLLINS, Alabama Polytechnic Institute.

The effect of fertilization on the crude fiber content and crude fiber–protein relationship of coastal Bermuda grass, W. J. MILLER, J. D. DONKER, AND M. STELLY, University of Georgia.

Nutritive value of Pearl millet silage preserved with various antibiotics, J. M. WING AND C. J. WILCOX, University of Florida.

The preservation and feeding value of Starr millet and Sudan grass silage for dairy cows, L. R. SISK, M. E. MCCULLOUGH, AND O. E. SELL, Georgia Experiment Station.

Factors affecting heifer performance on silage rations, M. E. MCCULLOUGH AND W. E. NEVILLE, JR., Georgia Experiment Station.

The effect of protein supplementation on the consumption and digestibility of sorghum silage. C. B. BROWNING, J. W. LUSK, AND J. T. MILES, Mississippi State University.

Relationship of lignin to other chemical constituents in Sudan and millet forages, A. S. ACHACOSO, C. L. MONDART, JR., F. L. BONNER, AND L. L. RUSOFF, Louisiana State University.

Effect of fiber content of the ration on the performance of dairy cows under hot and cool conditions, C. P. BREIDENSTEIN, J. E. JOHNSTON, G. A. HINDERY, AND L. L. RUSOFF, Louisiana State University.

Effects of protein content of the ration on hot-weather performance of producing dairy cows, R. E. LEIGHTON AND I. W. RUPEL, Texas Agricultural Experiment Station.

The effect of certain environmental factors upon milk production in Georgia, O. T. FOSGATE AND H. K. WELCH, University of Georgia.

The effects of potassium nitrite on litter size and growth rate of rats, L. J. BOYD AND S. LANE PARKINSON, University of Tennessee.

Nitrate poisoning of dairy cattle grazing oat forage, O. T. STALLCUP, R. ROBBERSON, O. H. HORTON, AND R. L. THURMAN, University of Arkansas.

Tuesday P.M.

DAIRY MANUFACTURING

Presiding: B. E. GOODALE

2:00–4:30 P.M.

Green Room, Bankhead Hotel

A study of consumer handling practices affecting the quality of ice cream and mellorine, CARL VANDERZANT AND RANDALL STELLY, Texas Agricultural Experiment Station.

The chloride content of milk, W. A. KRIENKE, Florida Agricultural Experiment Station.

Consumer preferences for cottage cheese, H. C. OLSON AND DOROTHY STROZIER, Oklahoma State University.

A survey of cottage cheese manufacturing operations in Alabama, R. Y. CANNON, Alabama Polytechnic Institute.

A study of the bacteriological and storage properties of cottage cheese, J. J. SHEURING, University of Georgia.

The rate of inoculum of cottage cheese and its influence on yield and manufacturing time, J. N. MORGAN, E. R. JARMAN, AND J. J. WILLINGHAM, Texas Technological College.

The use of frozen ripened lactic cultures in the manufacture of cottage cheese, J. H. MARTIN AND JOE T. CARDWELL, Mississippi State University.

Radiostrontium in dairy products, B. J. DEMOTT, D. G. EASTERLY, AND R. G. CRAGLE, University of Tennessee.

6:30 P.M.

Annual Banquet and Honors Program

Wednesday A.M.

JOINT SESSION

DAIRY PRODUCTION AND DAIRY MANUFACTURING

Presiding: G. S. PARSONS

8:30–11:00 A.M.

French Room, Bankhead Hotel

Effects of feeding aureomycin to lactating dairy cows, L. J. BOYD, H. D. BAXTER, J. B. MCLAREN, AND J. R. NICHOLS, Tennessee Agricultural Experiment Station.

Species of lipolytic anaerobic spore-forming bacteria found in milk and cream, B. M. MCCLURE AND E. R. GARRISON, University of Arkansas.

Daily observations on the summer production of fat and solids-not-fat by Jersey cows, J. C. JOHNSON, JR. AND R. L. GIVENS, Georgia Experiment Station.

Effect of varying quantities of feed on milk production in DHIA herds, W. S. GRIFFITH AND K. E. LOOPE, Virginia Polytechnic Institute.

Central machine processing of DHIA records in the Southeast, its advantages and limitations, M. E. SENGER, North Carolina State College.

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